T2
163

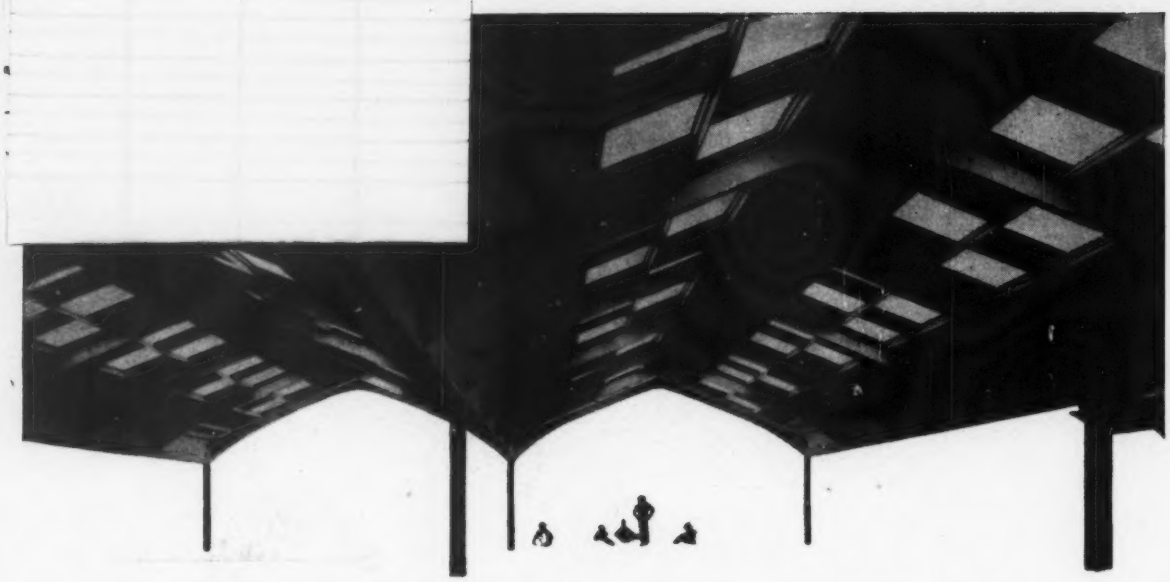
INDIAN JOURNAL OF POWER & RIVER VALLEY DEVELOPMENT

T2
163

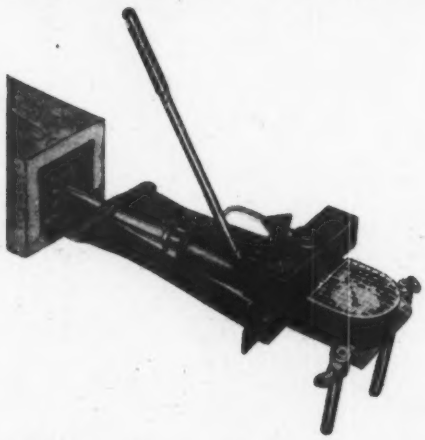
VOL. VIII. NO. 2 FEBRUARY, 1958 RUPEES TWO

THE JOHN CRERAR LIBRARY
JUL 22 1958

VERTICAL-LIFT GATE OF MOVABLE DAM : DELTA PLAN, HOLLAND



Big Beams Overhead ...built with ease by the GIFFORD-UDALL PRESTRESSING SYSTEM



The primary beams for this factory were pre-cast in light, easily handled sections which were supported on false formwork before stressing: heavy and expensive lifting tackle was thus avoided. The Gifford-Udall System shows considerable savings in steel and concrete wherever pre-stressed concrete has an application; the same equipment has been used for post-tensioning 90 ft. span beams and pre-tensioning 30 ft. poles No royalties are payable.

Typical northlight shell roof construction; edge beams post-tensioned by the Gifford-Udall prestressing system.

Sole Agents:

Killick, Nixon & Company Private Limited

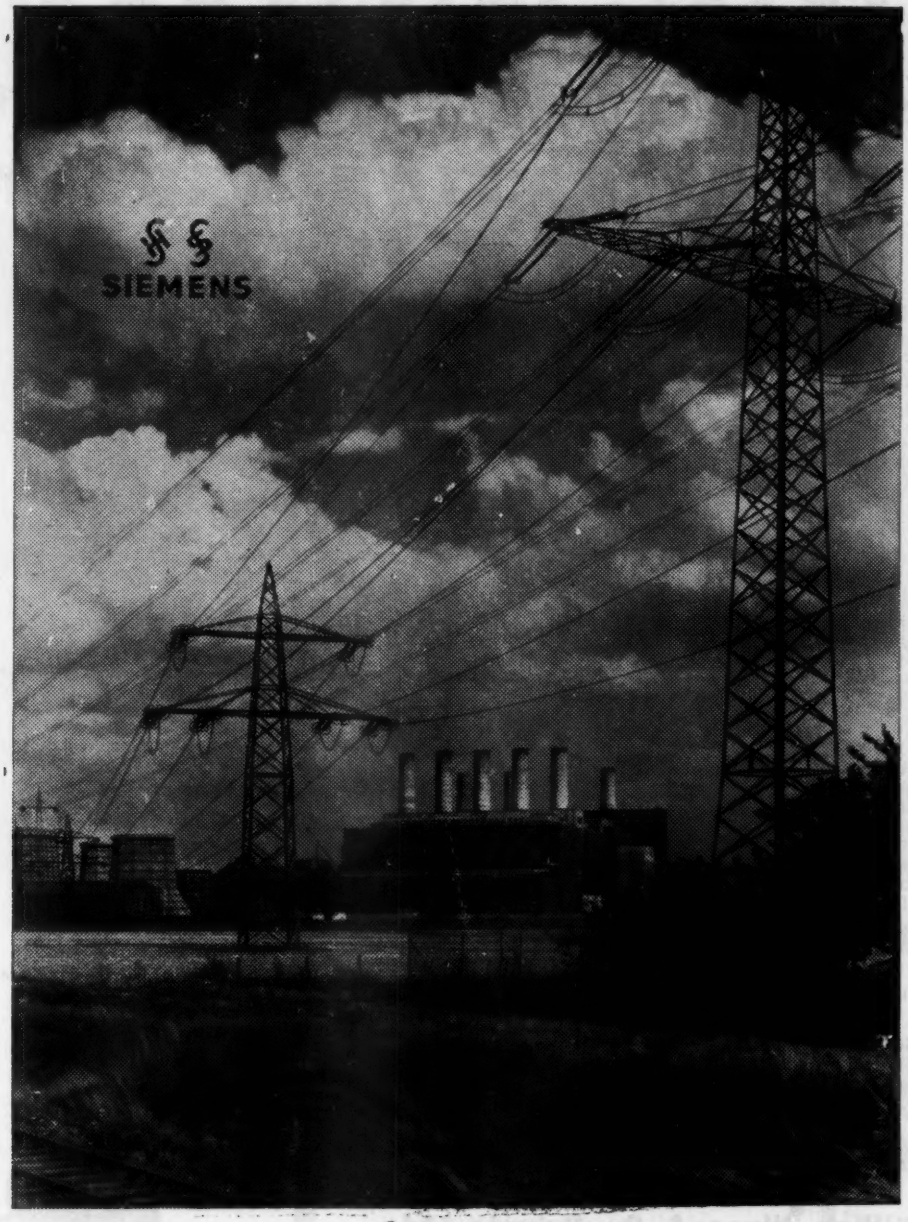
(A wholly owned subsidiary of Killick Industries Ltd.)

Killick House, Home Street, Bombay 1.

KILLICK'S ENGINEERING

K.N. 201

Delhi Office : C/o Bird & Co. (Private) Ltd., Post Box No. 65, New Delhi.
Calcutta : F-2, Clive Buildings, Post Box No. 719, Calcutta.
Madras : C/o Binny & Co. (Madras) Ltd., Engineering Department, P.O. Box No. 66, Madras.



SIEMENS & HALSKE AG - SIEMENS SCHUCKERTWERKE AG
WESTERN GERMANY

SOLE REPRESENTATIVES:

SIEMENS ENGINEERING & MANUFACTURING CO. OF INDIA PRIVATE LTD.

BOMBAY - CALCUTTA - NEW DELHI

a concrete example of

The compaction obtainable in a railway compartment, however unforgettable it may be, is nothing compared to the full compaction possible with Johnson vibration equipment.

The portable light-weight vibrator illustrated below has been designed after years of manufacturing experience based on supplying vibrators to this country; this experience has resulted in the evolution of a vibrator capable of achieving excellent results in compacting harsh, dry mixes. Compaction is rapid and certain; large numbers of these machines are being used all over India, on P. W. D. contracts, mass concrete work, as well as dock and harbour construction.

The vibrator can be driven by either a totally enclosed motor or by a petrol engine.

Experienced engineers and contractors know that for manufacturing concrete products or working on site, there is no machine to compete with the new Johnson vibrator

Manufacturers:
C. H. JOHNSON (MACHINERY) LTD., STOCKPORT, ENGLAND

Write for details to Sole Agents:

Killick, Nixon & Co. Private Ltd.

(A WHOLLY OWNED SUBSIDIARY OF KILLICK INDUSTRIES LTD.)

Killick House, Home Street, Bombay 1.

Delhi Office : C/o Bird & Co. (Private) Ltd., Post Box No. 65, New Delhi.
Calcutta : F-2 Clive Buildings, Post Box No. 719, Calcutta.
Madras : C/o Binny & Co. (Madras) Ltd., Engineering Department, P.O. Box No. 66, Madras.

with the NEW Johnson Model IIIA Concrete Vibrator

POWER UNIT: a 3 h.p. air cooled Villiers engine or a 3 h. p. motor.

DRIVE: by protected vee belt.

FREQUENCY: 10,000 vibrations per minute

FLEXIBLE SHAFT: Max. length 36'. A strong reinforced rubber sleeve surrounds the shaft. An unusual degree of flexibility is obtainable

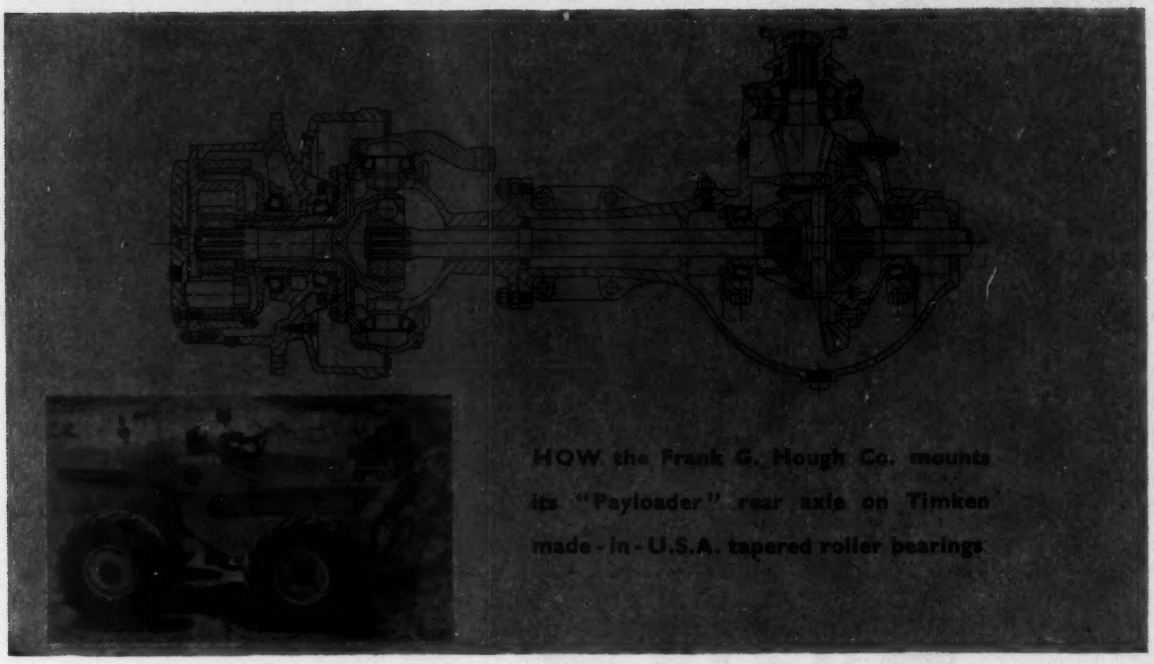
VIBRATOR: mounted on ball and roller bearings. The full length of the flexible shaft can be immersed

KILLICK'S ENGINEERING

TIMKEN Made in U.S.A.

TRADE-MARK ORIGINATED, OWNED, REGISTERED
BY THE TIMKEN ROLLER BEARING COMPANY

TAPERED ROLLER BEARINGS



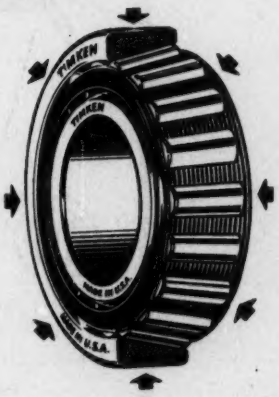
HOW the Frank G. Hough Co. mounts its "Payloader" rear axle on Timken made-in-U.S.A. tapered roller bearings

21,000 pounds of push, with Timken Bearings carrying the load

To help this "Payloader" exert up to 21,000 lbs. of *push* in moving sand, cement, etc., its builder, The Frank G. Hough Co., subsidiary of International Harvester Company, uses Timken made-in-U.S.A. tapered roller bearings. These bearings are used in transmission, front and rear drive axles, and wheels.

Like most manufacturers of heavy, road-building machinery, Hough uses Timken bearings because they: 1) *Have greater capacity.* Full line contact between rollers and races gives Timken bearings extra load-carrying capacity. The taper lets them take any combination of radial and thrust loads (as shown at right); 2) *Take shock.* Made of our special Timken analysis steel, Timken bearings are case-carburized to have hard, wear-resistant surfaces and tough, shock-resistant cores.

For bearings designed to last the life of your machine, specify Timken made-in-U.S.A. bearings. Made by the world's oldest and largest manufacturer of tapered roller bearings. *World-Wide Availability.* The Timken Roller Bearing Company, Canton, Ohio, U.S.A.
Cable: "TIMROSCO".

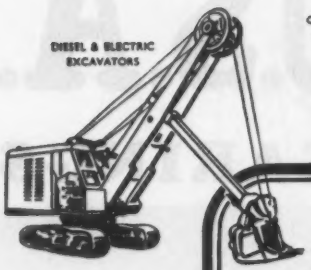


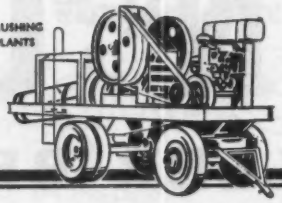
NOT JUST A BALL ○ NOT JUST A ROLLER ⊂⊃ THE TIMKEN TAPERED ROLLER ⊂⊃ BEARING TAKES RADIAL ↓ AND THRUST →⊂⊃← LOADS OR ANY COMBINATION

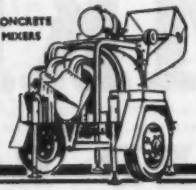
TIMKEN U. S. A. BEARING SERVICE

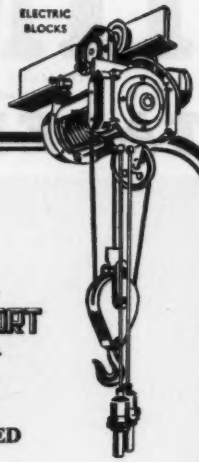
Distributors: **Voltas Limited.** Bombay • Calcutta • Madras • New Delhi • Bangalore • Cochin.

7-679









'Implementing'

the 2nd Five Year Plan...

We are proud to be associated with the industrial progress of India and are ready to contribute our mite towards the successful implementation of the 2nd Five Year Plan.

The implements and machinery manufactured by the world-renowned 'METALEXPORT' (Warsaw, Poland) are now at the service of our Nation. As pioneers in the production of every phase of industrial machinery—building or road construction machinery, air compressors or crushing machinery, flour milling, baking, or paper making machinery—METALEXPORT offers to supply the machinery requirements of our 2nd Five Year Plan adequately.

Manufactured by

METALEXPORT

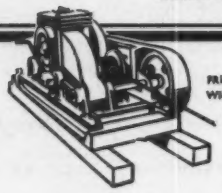
POLAND, WARSZAWA.

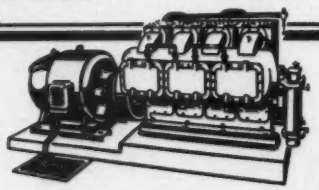
Selling Agents:

KHEMKA & COMPANY (AGENCIES) PRIVATE LIMITED

Vulcan Insurance Building, Churchgate Reclamation, Bombay 1

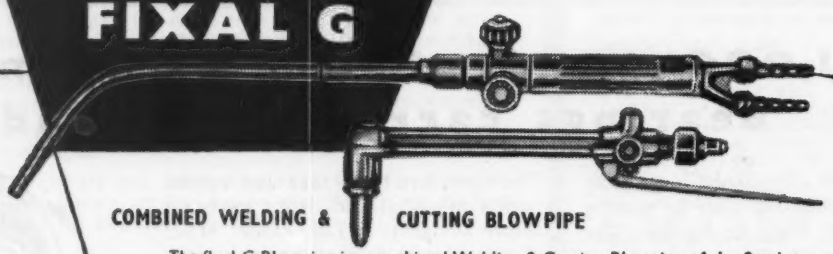
Branches at: New Delhi, Calcutta and Madras





KA-6

FIXAL G



COMBINED WELDING & CUTTING BLOWPIPE

The fixal G Blowpipe is a combined Welding & Cutting Blowpipe of the fixed capacity type for high and low pressure. Interchangeable welding & cutting heads may be readily attached to its body. Each welding head consists of a nozzle and an injector-mixer so designed to provide accurate oxygen & acetylene proportions to suit each nozzle. The cutting head does not require an injector, as mixing of the gases is completed in the nozzle.

Available in 2 combinations (a) 5 welding heads & 3 cutting tips & (b) 8 welding heads & 3 cutting tips. Maximum ranges of welding & cutting are

Welding 1/8" – 15/32" Cutting 1/8" – 4"

Welding 1/16" – 5/8" Cutting 1/8" – 4"

MANUFACTURED BY L'AIR LIQUIDE PARIS

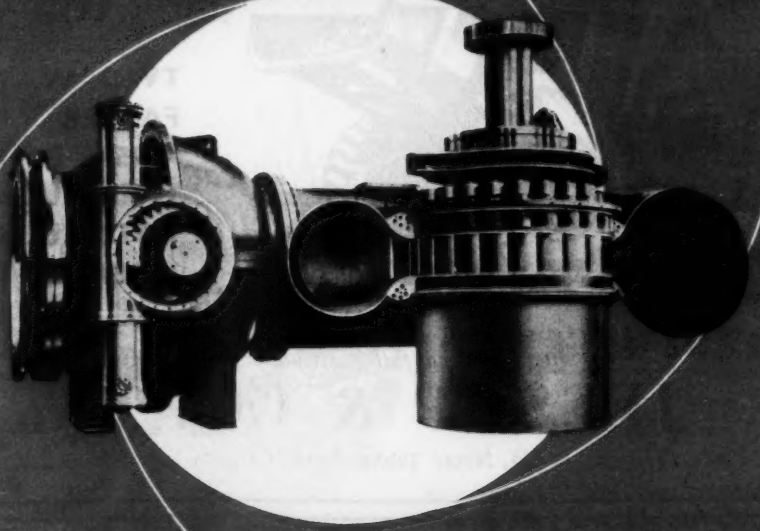
THE ASIATIC OXYGEN AND ACETYLENE CO., LTD.

8 DALHOUSIE SQUARE, EAST, CALCUTTA-1

AOAF-4-57

COMPLETE EQUIPMENT

FOR WATER POWER PLANTS



Turbines of the Kaplan, Francis and Pelton type for various heads and outputs, transformers, generators, outdoor and indoor switchgears, control-rooms, etc.

The world known SKODA and CKD Trade marks guarantee the first class technical design and quality of equipment supplied by us. We give integral guarantees for complete deliveries.

Local Enquiries to :

SKODA (INDIA) PRIVATE LTD.

Vulcan Insurance Building, Vir Nariman Road, Bombay-1

Branches :

Delhi Stock Exchange Bldg., Asaf Ali Road, D.A.C. Extension, New Delhi

P 35, Mission Row Extension, Calcutta-13

Agricultural Mansion, 35, Mount Road, Madras-2

Delivered by

TECHNOEXPORT

FOREIGN TRADE CORPORATION FOR EXPORT OF COMPLETE INDUSTRIAL PLANTS

56, Vaclavske namesti, Praha II

CZECHOSLOVAKIA

AVELING—BARFORD SHUTTLE DUMPER

9 cu. yd.
10 tons payload

It loads fast
It moves fast
It dumps fast

TWO-WAY STEERING
FASTER TRAVELLING
— 150 B. H. P. ENGINE
HYDRAULIC TIPPING
HYDRAULIC STEERING
CHEAPER TO OPERATE

For literature and full particulars please write :-

JESSOP & CO., LTD.

63, Netaji Subhas Road, Calcutta-1.

ATLAS COPCO AIR COMPRESSOR

Atlas Copco AR type compressors give more air to the horse power than any other machine, and reduce fuel consumption to the minimum. Extremely rugged in construction, these heavy duty stationary air compressors are easily adapted to variations in air demand.

OTHER FEATURES:

- *Low speed*
- *Low lubricating oil consumption*
- *Continuous service for even three shifts without the slightest loss of efficiency*

Enquiries to:

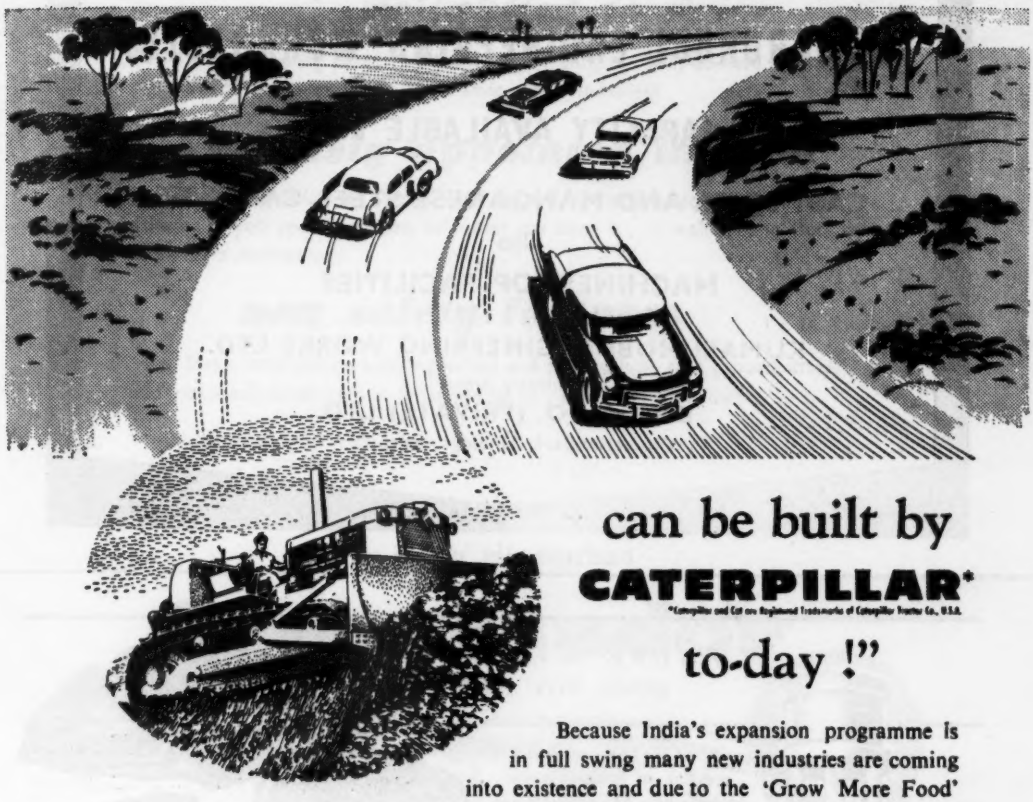
VULCAN TRADING CO. (PRIVATE) LTD.

19 British Indian Street, Calcutta.

Other Offices at : Bombay Madras New Delhi

ITC-29

"Our highways of to-morrow ...



can be built by CATERPILLAR*

*Caterpillar and Cat are Registered Trademarks of Caterpillar Tractor Co., U.S.A.

to-day !"

Because India's expansion programme is in full swing many new industries are coming into existence and due to the 'Grow More Food' campaign more food is being produced. More and more goods are being carried by road transport.

To open up new areas, to take care of the increasing traffic, new roads must be built and old roads have to be improved.

Better roads can be built with Caterpillar equipment. You do not save time by stopping the clock. Neither do you save money by buying cheap equipment. Caterpillar equipment will save you both time and money by giving you better output with less downtime and more economical operating costs.

Invariably a first choice among Government engineers and leading contractors, CATERPILLAR will, no doubt, play a leading part in building India's future Highways.

CATERPILLAR* *Paving the way to India's progress*

*Caterpillar and Cat are Registered Trademarks of Caterpillar Tractor Co., U.S.A.

TRACTORS (INDIA) LIMITED
Post Box 323, Calcutta
Post Box 66, Lucknow

LARSEN & TOUBRO LIMITED
Post Box 278, Bombay
Post Box 5247, Madras

WILLCOX (BUCKWELL-INDIA) PRIVATE LIMITED
Post Box 289, New Delhi
New Colony, Jaipur

TRACTOR & EQUIPMENT CORPORATION (PRIVATE) LIMITED
P.O. Box 279, New Delhi

T11/P/53

KUMARDHUBI ENGINEERING WORKS LTD.

CAPACITY AVAILABLE FOR

CAST STEEL AND MANGANESE STEEL CASTINGS

also

MACHINESHOP FACILITIES

KUMARDHUBI ENGINEERING WORKS LTD.

Managing Agents :

BIRD & CO. (PRIVATE) LTD.

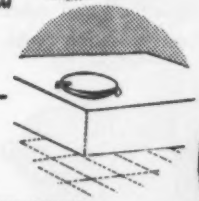
Chartered Bank Buildings, Calcutta 1

B 1525 R

WHERE NATURE DOES NOT HELP

OVERHEAD RESERVOIR

DAM



UNDER GROUND RESERVOIR

Use CICO for complete water-proofing of reservoirs, safe deposit vaults, Dams, Buildings, Roads, Bridges etc. and save them from corrosive fungoid growth, efflorescence and injurious chemical actions. ● *CICO is a wonderful preparation for cement rendering and concreting under water and against pressure*

Pronounced CHĒ-KO

CICO

REGD

THE STRUCTURAL WATERPROOFING CO. PRIVATE LTD.

Phone—47-2684 21-1, Dover Road, Calcutta-19 Grams—"Aquaproof"

SAFE DEPOSIT VAULT

THE BEST CEMENT

WATERPROOFING COMPOUND

PPS/BWC-103/57-S

Selling Agents :—

ECLIPSE ENGINEERING CO., for Bombay

R. M. & CO., for M.P. (Except Bhopal).

BIRD & CO., PRIVATE LTD., for Punjab, Pepsu and Himachal Pradesh

GILLANDERS ARBUTHNOT & CO., LTD. for Madras, Delhi, U.P., Bhopal, Rajasthan, Jammu and Kashmir.

GLADSTONE LYALL & CO., LTD. for Assam, Bihar, Saurashtra and Andhra.

elegant in looks

Here's a combination of modern styling and traditional dignity . . . dramatic air-flow contours on the bonnet and flaired tail-fin fenders.

delightful to drive

Astonishing handling ease . . . smoother gear shift . . . easy-to-read, easy-to-reach grouping of instruments and panoramic-view windshield.

luxuriously appointed interior

Richly upholstered in matching colours . . . automatic courtesy light goes on as you open the door, off when you close it . . . well-sprung seats with latex-foam cushioning.

new safety features

Deep-sunk-centre steering wheel and padded facia rails protect driver and front-seat passengers in emergencies . . . safety glass all round.

You are invited to test-drive

The NEW Hindusthan

Ambassador

HINDUSTAN MOTORS LTD.

PRICE
Rs. 11,161/-
(EX-PLANT)

HM-2/58.

Dealers at :

Agra, Ambala Cantt., Ajmer, Ahmedabad, Allahabad, Baroda, Bangalore, Bombay, Bareilly, Banaras, Calcutta, Cuttack, Coimbatore. Dibrugarh, Gauhati, Indore, Jaipur, Jodhpur, Jalgaon, Jorhat, Jamshedpur, Jullundur City, Jammu, Kanpur, Kolhapur, Lucknow, Madras, Madura, Mangalore, Meerut, Manbhum, Nagpur, New Delhi, Nepal, Patna, Poona, Palayamcottai, Pondicherry, Rajkot, Ranchi, Satna, Sambalpur, Shillong, Secunderabad, Silchar, Srinagar, Tezpur, Tiruchirapalli, Trivandrum, Vijayawada, Vizianagram City.

SPECIAL NUMBER

of

INDIAN JOURNAL OF POWER & RIVER VALLEY DEVELOPMENT

MADRAS STATE ELECTRICITY DEVELOPMENT—an authoritative reference publication covering all aspects of electricity development in Madras State.

Contributors include :

V.P. Appadurai, Chief Engineer, Electricity, Madras ; H. Raghavendra Rao; T.V.S. Warrier ; V.T. Arasu; Mohammad Ali and other officers of Madras Electricity Department.

Date of publication :

To be published on the occasion of the opening of the Periyar Hydro-Electric Project in August, 1958.

PRICE : RS. 3/00

Place your orders with :

The Manager,

INDIAN JOURNAL OF POWER & RIVER VALLEY DEVELOPMENT

6/2, Madan Street, Calcutta 13.

BUMPER SPECIAL ISSUES OF INDIAN MINING JOURNAL

"COAL INDUSTRY IN INDIA"—carrying 45 Papers by leading authorities, read at the symposium on India's Coal Industry organised jointly by the Geological, Mining and Metallurgical Society of India and Indian Mining Journal. The articles provide a valuable and comprehensive survey of the coal industry in India. **Price Rs. 7/8/-**

"COAL WASHING IN INDIA"—carrying 23 Papers read at a symposium on Coal Washing organised by Central Fuel Research Institute. These contributions by experts in the field of fuel research make an almost exhaustive study on a high technical level of all aspects of coal washing in India. **Price Rs. 5/-**

"ECAFE NUMBER" carrying articles on many important aspects of geology and minerals by officers of the Geological Survey of India—published in commemoration of ECAFE meetings on Geological Map and Mineral Resources Development of Asia and the Far East, held in Calcutta from Nov. 4 to 16, 1957. **Price Rs. 5/-**

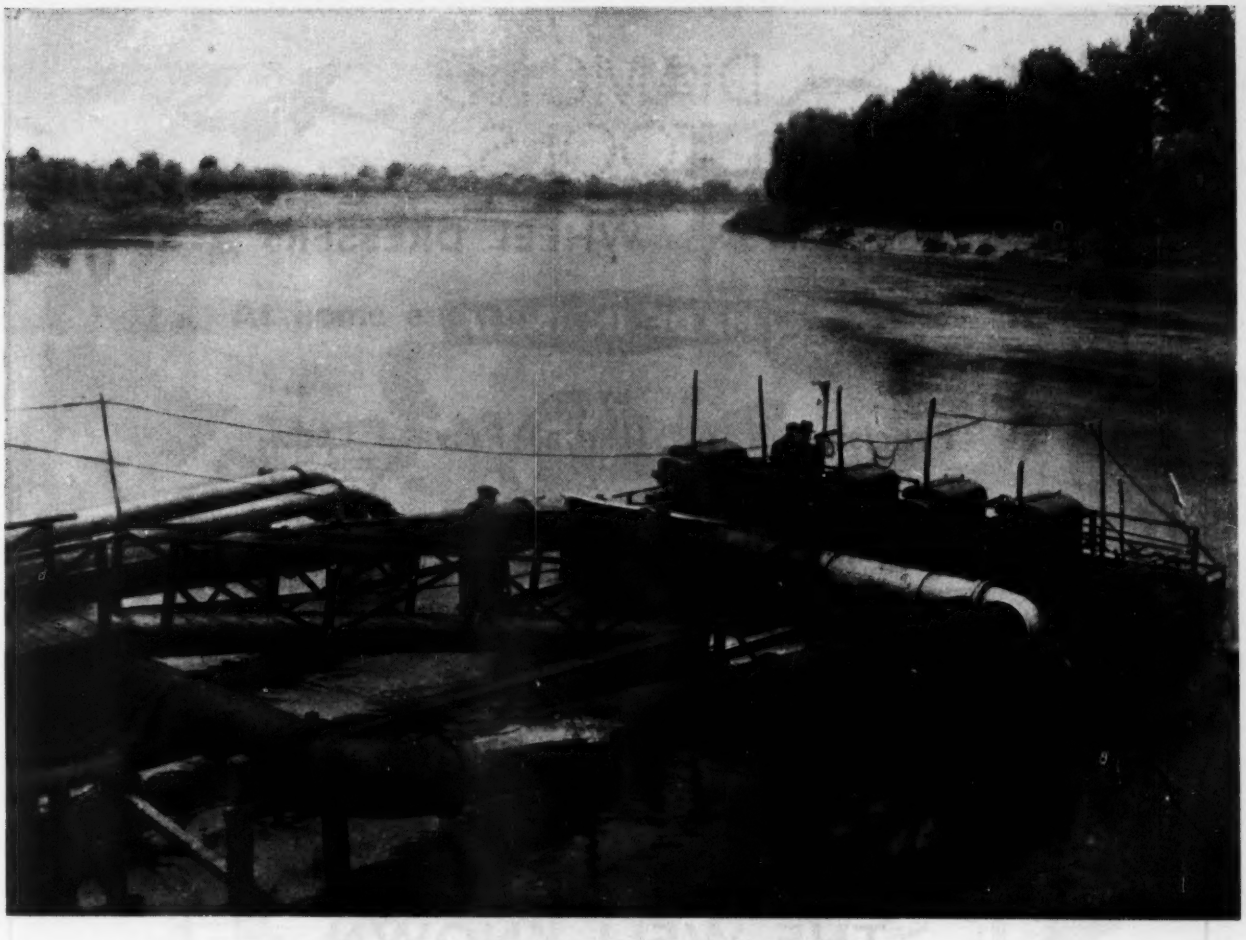
"MINERAL BENEFICIATION & EXTRACTIVE METALLURGICAL TECHNIQUES"—carrying 57 Papers from eminent scientists and technologists read at a symposium held at the National Metallurgical Laboratory, Jamshedpur, from February 8 to 11, 1957. **Price Rs 15/-**

Place your orders with :

Manager

INDIAN MINING JOURNAL

6/2, MADAN STREET CALCUTTA-13



FLOATING PUMP-STATIONS

Particularly suitable for lifting over considerable water-quantities, for inundation, artificial irrigation as well as for regulating inland-waters.

Several pump-units are placed on one float and these press the water in a common collecting main. The flexible knee-joints render it possible that the pump-stations can be kept in operation during the whole season without being mounted or dismounted also in the case when the water-level rises or sinks.

Exporters :

»TECHNOIMPEX«

HUNGARIAN MACHINE INDUSTRIES FOREIGN TRADE COMPANY

BUDAPEST 62, P. O. B. 183, HUNGARY. Cable : TECHNOIMPEX, BUDAPEST

For further enquiries please contact :

1) The Trade Representative of the Hungarian People's Republic in India, 18, Golf Link Area, New Delhi.

2) The Trade Commissioner of the Hungarian People's Republic, "Revills", 45, New Cuffe Parade, Bombay.

DIAMOND TOOLS

DRILL BITS WHEEL DRESSERS

MADE IN INDIA

by

Precision Tools (India) Private Ltd.,

under licence from
Triefus Industries Ltd.,
Crawley U.K.

Sole Selling Agents in India

Kilburns

MINING EQUIPMENT SPECIALISTS

KILBURN & CO. PRIVATE LTD.
2, Fairlie Place, Calcutta-1

THE WELL-KNOWN
PIKROSE HAULAGES

(Electric and Compressed Air)

ARE NOW MANUFACTURED IN INDIA

UNDER SPECIAL LICENSE FROM THE MANUFACTURERS, MESSRS. AUSTIN HOPKINSON & CO. LTD., ENGLAND

BY

KILBURN & CO. PRIVATE LTD.

2, FAIRLIE PLACE, CALCUTTA-1

THE increasing demand for Kirloskar Engines is justified by their widespread popularity in the foreign countries, such as Cyprus, Persian Gulf, Middle East, Indonesia and Africa. Kirloskar Engines are designed for faultless performance. Economical in price and operation, these engines have gained in prestige at home and abroad and secured a pride of place for the field of Indian Industry.

KIRLOSKAR OIL ENGINES LTD., KIRKEE, POONA 3

KOEL/E-1/57

TOM & BAY (Advtg.) Ltd.

BABCOCK

The

"STEAMBLOC"

fully automatic packaged boiler

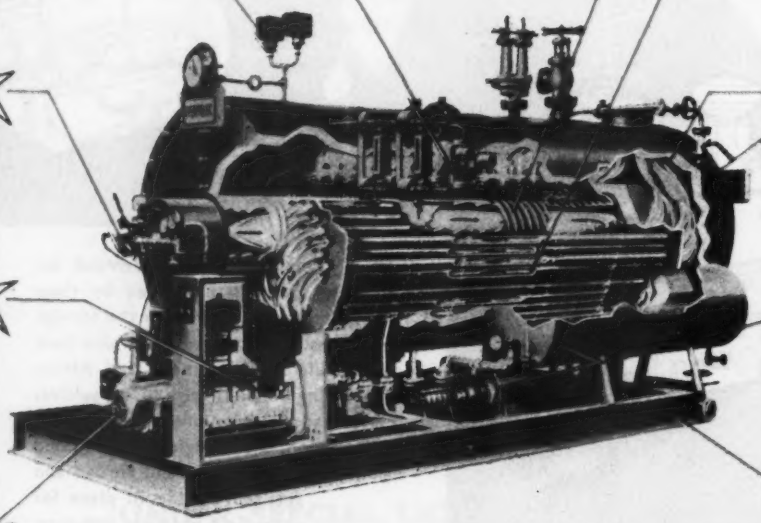
TWIN MOBREY CONTROLLERS providing close control of water-level with complete shutdown and alarm on low water.

MODULATING PRESSURE CONTROL maintaining operating pressure within close limits and incorporating high-pressure safety shutdown.

OIL BURNER of the well-proved fully-modulating pressure-jet type with gas-electric ignition and photo-electric cell for flame failure shutdown. Capable of utilizing the heaviest grades of fuel oil available.

CONTROL CABINET Electronic and electro-mechanical devices ensure safety in operation and provide for purging of the gas passes before starting up, and total, immediate shutdown in the case of flame failure, low water or excessive steam pressure.

FORCED-DRAUGHT FAN providing air for pressure combustion and thus obviating the use of an induced draught fan and a costly chimney stack.



Fully described in publication No. 1628/2 which will be sent on request

PARTIALLY CORRUGATED FLUE for flexibility, with plain section at the burner end for maximum combustion efficiency.

THREE-PASS BOILER of all-welded construction to Class I requirements. The three passes provide high efficiency, maximum heat transfer and quick steaming.

BOILER INSULATION consisting of a layer of high quality thermal insulation, overlaid with sheet steel cleading, presenting a neat and attractive appearance.

REAR DOOR carried on davits for easy removal; providing full access for maintenance and cleaning.

BOILER FEED SYSTEM comprising supply tank, electrically-driven feed pumps and standby steam-operated injector. A float valve is provided in the tank.

STEEL BEDPLATE carrying the complete boiler unit, allowing easy transportation and quick installation.

BABCOCK & WILCOX OF INDIA (PRIVATE) LIMITED

4, BANKSHALL STREET
CALCUTTA-1

16, QUEENS ROAD ESTATE
BOMBAY

INDIAN JOURNAL OF POWER AND RIVER VALLEY DEVELOPMENT

A MONTHLY DEVOTED TO DEVELOPMENT OF POWER & WATER RESOURCES IN ASIA

Editor : K. K. Sinha

P. K. Menon : Mg. Editor

VOL. VIII **FEBRUARY 1958** **NO. 2**

CONTENTS

ELECTRIC SUPPLY INDUSTRY AND THE ROLE OF THE PRIVATE SECTOR	*S. K. Patil*	1
KRISHNA BARRAGE PROJECT	*G. A. Narasimha Rao*	3
THERMAL POWER STATIONS	*D. C. Bhardwaj*	7
BIN-EL-OUIDANE HYDRO-ELECTRIC POWER STATION, MOROCCO	*Galletout and Bergougnan*	13
CALCULATION WITH THE ENERGY-HEAD	*P. G. Franke*	19
ISRAEL'S MASTER PLAN FOR IRRIGATION		25
ASIA'S LARGEST RUBBER FACTORY		27
RADIATI N LABORATORY FOR RUBBER INDUSTRY		28
C. A. PARSONS CO. LTD.		30
LETTER TO THE EDITOR	*N. S. Joshi*	30
TWO MAJOR LESSONS	*Editorial*	31

The coming issue :

Andhra Pradesh Electricity Development Number

Editorial and Managerial Offices
6/2, MADAN STREET, CALCUTTA-13. PHONE : 23-1765 & 23-5855. GRAM : TEKJOURN
Manager : B. Bhattacharya

Bombay Office
41, Hamam Street
Bombay 1
Phone : 252119

German Representatives
Linder Presse Union G. M. B. H.
Frankfurt/Main, Wittelsbacher Allee 60
W. Germany.

London Representatives
Walter Judd Ltd.
47, Gresham Street
London E C 2

Annual Subscription : Rs. 20, £2 or $6.00. *Single copy : monthly issue* Rs. 2

INTERNATIONAL HARVESTER

Payscrapers

MAKE EVERY JOB A "PLANNED SUCCESS"

International Payscrapers symbolise the dependable, mighty power which carries away immense loads of earth with remarkable ease at high speeds. They have been designed and built to give you higher output at lower costs.

Many special features make IH Payscrapers the best choice the world over.

Loading and unloading are faster, easier with straight line pushing from crawler to cutting edge, straight line reeving and positive rolling ejection. An operator does more work with improved hydraulic steering, new sure-action cable control unit and positive air booster clutch together with unrestricted visibility and comfort riding.

INTERNATIONAL CONSTRUCTION EQUIPMENT

Backed By **VOLTAS** *unrivalled service and spare parts organization*

VOLTAS LIMITED

BOMBAY • CALCUTTA • MADRAS • NEW DELHI • BANGALORE
COCHIN • AHMEDABAD • SECUNDERABAD • LUCKNOW

Electric Supply Industry and the Role of the Private Sector

By S. K. PATIL

At the very outset, I must express my great pleasure to be in the midst of, may I describe, the significant contributors to the industrial prosperity of this land. I say so in all seriousness and with the responsibility that attaches to the office that I hold. You have made significant contribution; you will continue to make these contributions and in that process I think it is Government's duty to be of help to you in every possible manner. Having said so, I must mention that I did not come here with a view to giving you any advice. You know about electricity much more than I do. It is a sheer accident in my life that I have come to be attached to the Ministry dealing with electricity, but having done so, I must take care that I do not get an electric shock ! I have been trying for the last seven months to avoid getting any such shock.

Now I shall give you an account of the picture that I have been able to assess during the last seven months that I have been holding this office in the Government of India as to how much progress—and when I say progress, not a very significant progress according to me, but such progress as we have been able to make during the last seven or eight years. Then I shall come to some of the problems that you have raised in the helpful and constructive speech of yours.

You have read in the Five Year Plans—the First and the Second—the targets of achievements that we had fixed for ourselves, and so far as the First Plan is concerned they have been very nearly fulfilled. We are hoping that so far as the targets of the Second Plan are concerned we shall be able to do so notwithstanding the forein exchange crisis of which you have made a mention. At the beginning of the First Plan, the total power generating capacity installed in the country was of the order of 2.3 million kW and for which thanks and compliments go largely to the Private Sector. They were responsible largely in bringing into fruition the additional electricity. Now these 2.3 million kW comprise 1.7 million kW in the Public Utility Undertakings and 6 million kW in the industrial establishments. At the end of the First Plan period the installed capacity in Public Utility Undertakings was raised from 1.7 million kW to 2.7 million kW, nearly a rise of about 60% and the total capacity of generating plants of the industrial establishments rose to. 7 million kW, thereby bringing the total installed capacity in the country from 2.3 million kW before the First Five-Year Plan to 3.4 million kW, i.e. a raise of 1.1 million kW at the end of the First Five-Year Plan. During the Second Five-Year Plan, a total of 3.2 million kW, including certain schemes which were spilled over from the First Plan, is proposed to be commissioned in the Public Utility Undertakings, and the corresponding increase in the industrial establishments is estimated to be of the order of 3 million kW. Installation in the Second Five-Year Plan will comprise 1.3 million kW Thermal Plant and 2.2 million kW Hydro Plant. The total capacity at the end of the second Plan will be 6.9 million kW i.e. exactly three times the total capacity before the Plan began. This is a significant contribution. I do not attach much importance to this as compared with the rest of the world we are so far behind. The per capita power generation of our country as compared to the generation of other countries in 1956 reflect the following position :

Norway	6610 kWh
Canada	4860 ,,
Sweden	3470 ,,
U.S.A.	3320 ,,
U.K.	1571 ,,
Japan	712 ,,
India	25 ,,

The per capita generation in India in 1951 was only 17 and in 1956, i.e. at the end of the First Five-Year Plan, it has come to 25. At the end of the Second Plan we hope to make it 54. Among the States highest per capita generation in 1956 was in Delhi with a figure of 123.1 kWh with Assam having the lowest figure of 1 kWh.

The figures Statewise before the Reorganisation were:—

		kWh
	Andhra	6.1
	Assam	1
	Bihar	10.9
	Bombay	71
Central Administered areas.	Delhi	123.1
	Rest	3.2
	Hyderabad	3.6
	Jammu & Kashmir	5.9
	Madhya Bharat	5.4

Madhya Pradesh	10.8
Madras	27.9
Mysore	79
Orissa	1.1
Pepsu	.9
Punjab	25.5
Rajasthan	4.5
Saurashtra	16.4
Travancore-Cochin	36.9
Uttar Pradesh	10.3
West Bengal	65.9

Private Sector has played a notable part, particularly in Bombay and Calcutta, where the Private Sector has largely been responsible for the generation and distribution of power and the Private Sector is playing an important role even today. I do not rule out by any stretch of imagination the responsibility of the Private Sector in this particular field. I am not unfriendly to the Private Sector, and in fact, if an emphasis can be laid, I think I am a little more friendly to the Private Sector because I believe that in a mixed economy the Private Sector has an important role to play. We shall give them fullest scope to act.

Coming to the rural electrification, progress in this country is indeed very very poor ; so poor that I am even ashamed of quoting these figures.

We have 5,60,000 villages in this country after the partition. Out of this 5,60,000 villages, only 3,000 villages were electrified at the beginning or before the Plan. At the end of the First Plan, we registered some progress, but a very insignificant progress from 3,000 villages we came to 6,500. At the end of the Second Plan, we want to take this figure up to 10,000 more villages, bringing the total to 16,500 villages. Now in this scheme of rural electrification, it is necessary that subsidy must be given to the Licensees so that they shall be able to do their part in the development. When I say so, you need not at once jump to the conclusion that it is the decision of Government to render assistance to the Licensees. But if you want to know the lines on wnich I have been thinking, I think it is important that the Licensees in the field should be encouraged. I think with the collaboration of the State Governments and the Licensees we can expedite rural electrification scheme.

Yoy have referred to the foreign exchange difficulty. Everybody knows that an acute foreign exchange crisis has developed in the country and consequently there has been a serious hold up in the progress of power development. Sometimes you hear of the "core" of the Plan, and sometimes reference is made to the "hard core." The reality is we have now resorted to categorisation. This categorisation is a process which is not something that is arbitrarily decided upon.

Naturally Category No. 1 will include the Projects like Bhakra-Nangal on which lot of money including foreign exchange has already been expended and which require some further expenditure for bringing them into completion. This will be categorised as A. They must have precedence over the others.

Under B will be included projects which are sponsored by organisations like the World Bank, T.C.M., etc.

Under category C, which is known as the "core" of the Plan, are included the Steel Projects, Railways, Coal and ancilliary power.

Category D includes whatever that is not included in all the categories mentioned above.

These categories are all essentially meant for the guidance of the Planning Commission.

With regard to import of plant and machinery on deferred payment basis, the main point is that we will have to pay heavy interest. It is a dangerous proposition, but I am hoping that the crisis will not last long. The problem to be solved will require the help of everybody.

You refer to the creation of Deferred Taxation Reserve and things of that kind. The Government have got a view about it. We do not stick to it, but I will explain it.

The Industry has been pressing for the amendment of the Electricity (Supply) Act, 1948, to enable the Licensees to create a Reserve in which the relief in taxation available to them in earlier stages in the form of Depreciation Allowances could be used for paying increased taxes in later years. The proposals, however, have not found favour with Government as the Act entitles the Licensees to charge all taxes and increase in taxation, if any, in later years to be charged to the consumers in case the revenue does not increase as a result of the expansion in the industry. Experience, however, indicates that the business of electricity supply expands considerably towards the later years yielding additional revenue which would offset the effects of increased taxation without necessitating the enhancement of rates of electricity. The creation of the Reserve, if permitted, would result in an immediate increase in the existing rates of supply, according to my Department, approximately 28%. Electricity being a primary tool of Industry, any increase in its rates will add to the existing trend of inflation by adding to the cost of our goods, and raising the standard of living of the masses. If the Licensees can by some means ensure the creation of the proposed Reserve without raising their existing rates, there may not be any objection to their being permitted to do so, but this will require to be studied further.

Now I can tell you that the part played by Private Sector in the Electricity Supply Industry is a great one of which we are proud and it is a part which we want to ensure even for the future. Although State Governments are increasingly participating in electric development, the Private Sector continues to have a large share in the country. On the lst of January, 1956, last year the Private Sector owned 43.7% of the total installed generating capacity of all public utility undertakings in the country. Also the actual generation from these undertakings amounted to 46.8 of the total generation in the country.

When Tatas formulated plans for power development at Trombay we were only happy that Government's burden was lessened. In the realm of river valley projects, if the private sector were to come forward to take on assignments, they will be only

Continued on page 18

Krishna Barrage Project

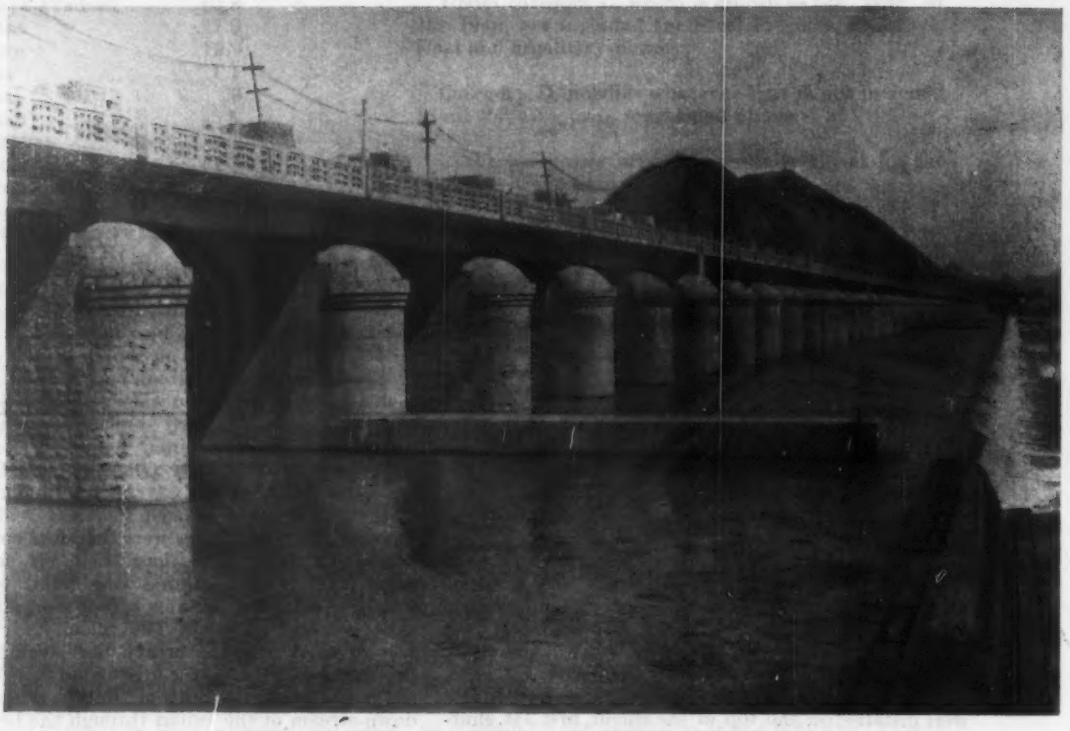
By G. A. NARASIMHA RAO

The story of the Krishna Barrage begines exactly one hundred years after the Krishna Anicut was constructed. In September, 1952 the Krishna Anicut was completely damaged in floods and the anicut body wall breached.

The Krishna Anicut built in 1852-'55 was found unsuitable to cater to the phenomenal increase in ayacut under the anicut. When it was built, the ultimate ayacut was envisaged to be 5.8 lakhs acres. This figure of 5.8 lakhs was reached even by 1894, much earlier than anticipated and therefore, shutters were installed on the top of the anicut, first 3 ft. shutters in 1898 and later 6 ft. shutters in 1925. The present 6 ft. falling shutters were to cater to an ultimate ayacut of about 8 lakhs of acres. But even this ayacut was soon exceeded. There was need to replace the existing 6 ft. shutters by 8 ft. shutters. But the anicut was found unsafe even for the existing 6ft. shutters as the anicut was not originally designed to withstand the pressures resulting from 6 ft. shutters. While the problem of installation of 8 ft. shutters in replacement of the 6 ft. shutters was under consideration, a sudden flood completely damaged the anicut and caused a breach in the body wall of the anicut, besides causing several huge scours all over the aprons. The Breach occurred on 4th September, 1952 and water was fiercely flowing through the breach, making the breach wider and wider every minute. The paddy crop in the fields over nearly ll lakhs of acres were only three months old and they required water for three more months. Floods could be expected in the river in October and November also, and those floods were likely to wash away a huge length of the anicut body wall, making it impossible to restore the anicut during the short period of 3 months of low flows, before the advent of next floods in June. It was therefore necessary to close the breach immediately within two to three weeks if possible, as otherwise, crops on atleast 7 lakhs of acres would perish for want of water. That alone represents 5½ lakhs of tons of rice valued at Rs. 14 crores.

The then Superintending Engineer, Sri Vepa Krishna Murthi, with his Executive Engineer, Assistant Engineer, Supervisor, Maistries and Lascars lost their lives while attempting to close the breach. There was tremendous panic, as it would be impossible to replace the loss on account of 7 lakhs of acres of paddy crop, when there was world shortage of paddy; even assuming that there was foreign exchange for buying it.

Several expert engineers were therefore consulted and several of their suggestions tried, viz. forming ring bund with earth, forming ring bund with stones, dumping crates and drums full of stones etc. But all those were of no avail. The velocity of the current was so great near the breach that even huge stones dropped a hundred yards upstream of the breach were not going down to bottom, but were being drawn down-stream of the anicut through the breach. Even big drums filled with stones were floating like paper through the breach but not sinking down. The depth of water upstream of the anicut was nearly 30 ft. and width of the breach was 130 ft. and therefore, it would have taken several months to form a ring bund either with stones or with earth, and meanwhile the existing paddy corps in the Delta would have perished. A unique method was therefore adopted. I have drawn inspiration for this process when as an engineering student, I noted with admiration and wonder the method adopted on the advice of the great engineer Sir M. Visweswarayya of quickly and economically erecting a groyne wall at the entrance of Vizag Harbour, by scuttling an old steamer. Attempts were made to adopt a similar method, as loaded steel barges (punts) weighing about 30 tons would be heavy enough not to be drawn down the breach. The problem was how to sink them near the breach. Old punts (steel barges) available in the delta were loaded with stones and let down from a steamer securely anchored in the river bed nearly half furlong upstream of the breach. When the punts reached a point sufficiently near the breach, holes were cut on the sides of the punt by oxy-acetylene flame by what I may call a suicide squad. The men who cut the whole would then jump out and be picked up by a small fast moving powerful launch. Due to the holes cut, the punt would begin to sink. The punt which was tied to the steamer by steel ropes would be released from the steamer by cutting the ropes at an appropriate time so that the punt would move forward while going down and reach the bed of the river exactly at the breach-site. The first punt was released too soon, and it passed down the anicut without sinking at the breach; the second punt was released too late and it sank in the river, far above the breach. After trial and error, the technique was perfected and the punts were made to sink exactly at the breach, by split second accuracy



Downstream view of Krishna Barrage from right flank.

in timing the release of the wire ropes. In all 42 punts loaded with stones were sunk and the intervening spaces between punts filled with rough stone. The breach was closed in a short period of 12 days, i.e. on the 24th of September, 1952 and water was rushed just in time to save the dying crops on seven lakhs of acres.

Then in the summer in 1953, the serious problem of how to remove the sunken punts for re-constructing the breached portion of anicut body wall baffled the engineers. The time available before the advent of next floods was only 3 to 4 months. The first attempt was to put up an earthen coffer dam and dewater but it resulted in the anicut body wall adjacent to the breach collapsing due to the powerful withdrawal of sand from underneath the foundation of the anicut. The only way to tackle the problem was to remove the punts by cutting them into pieces under water by divers with the help of underwater cutting apparatus with oxy-hydrogen flame. There was only one such apparatus available in India at Cochin harbour. It was obtained and local men were trained in the art of cutting under water with the oxy-hydrogen flame. Thus, by employing a large number of divers, the stones in the punts were removed one by one, and by employing underwater cutters, the punts were all cut to pieces and removed. Then the anicut body wall rebuilt.

Well sinking in progress in the regulated reach.

The reconstruction of the balance of scoured aprons of the anicut with cement concrete stepped aprons was also done departmentally after boldly rejecting 26 tenders received as they were much higher than the estimate. The outturn for the Departmental labour was 10 to 15 per cent above the schedule and therefore the work estimated to cost Rs. 40 lakhs as per schedule of rates was completed with a savings of Rs. 5 lakhs.

This was possible on account of prompt weekly payments made to the labour and good treatment given to the labour.

Need for the Barrage

One may ask the question : What was the need for the Barrage in as much as the anicut was thoroughly repaired ? The main reason is that the anicut is not safe even for the existing 6 ft. shutters as seen by the face that the river bed below the anicut scoured down

HYDRAULIC PARTICULARS

Location :—104·5′ Upstream of existing anicut shutters.

Regulator :—

(a) Length : Regulator 3400′-0″

Scouring Sluices :

Right side 122′-0″

Left side 144′-0″

Total 3736′-0″

(b) Vent-way :

Regulator 70 Nos. of 40′-0″ each.

Scouring Sluices : 6 Nos. of 17′×12″ each of left side.

8 Nos. of 17′×12″ each on right side.

(c) Levels :

Floor of Regulator	+40.05
Floor of Scour vents	+36.30
Sill of Regulator	+45.05
Top of Regulator Gates	+57.05
Average bed level of river	+37.00
Bottom of floor of Regulator	+33.55
of scouring sluices :	
Right Side	+28.80
Left Side	+31.80
Bottom of wells	+16.00
Top of roadway on bridge	+82.10
Top of Hoist Bridge	+99.60

(d) Wells : Total number of wells in all the three rows : 900

Each well has 2 chambers 4′×4′ with over all dimensions of 7′-0″×12′-6″

Upstream well depth 16′-0″

Middle and downstream 20′-0″

(e) Superstructure :

Piers	8′-0″ thick
Intermediate piers in Scour Sluices	6′-0″ thick
Abutment piers with R. C. Stair case inside (8 Nos.)	14′-0″ thick

(f) Catchment area of Krishna River : 97,050 Sq. miles.

(g) Maximum flood discharge :

M. F. L. Recorded upstream of Krishna Anicut on 7-10-1903 +70.55

Do (Downstream) +68.00

Maximum calculated discharge 11.9 lakhs cusecs.

(h) Afflux due to interposition of Barrage : 2.16 ft.

(i) Ayacut : Existing 11 lakhs acres.

Additional expected 1 lakh

Bridge : Road way 24′-0″ between kerbs.

Footpaths 5′-0″ on either side.

Materials : Cement 44,000 Tons.

Steel 8,000 Tons including sheet piles.

Plant & Machinery Rs. 8 lakhs net.

Comparative Study of Cost and Time of Construction of Various Barrages in India

Name of Barrage	River	Maximum discharge of River	Length of Barrage	Vent way	Height of Shutters	Road way	Quantity of Construction Materials	Cost	Period of Construction
Krishna Barrage	Krishna	11.9 Lakhs cusecs.	3736ft. of Barrage. (Road Bridge 4045 ft.)	70 bays 40′ span each separated by 8′ piers for Regulator and 8 bays 17′ span on right flank and 6 bays of 17′ span on left flank for scouring sluices, each separated by 6′ Piers.	12 ft.	24′ clear width with 5′ foot paths on either side.	71 Lakhs Cft. of Concrete & Masonry.	266.31 Lakhs for works and 284.15 Lakhs including Indirect charges.	3½ Years. (Working time nearly 6 months each year.)
Nangal Barrage	Sutlej	2.76 Lakhs Cusecs.	955 ft.	24 bays of 30′ span each separated by 7′ piers for Regulator and 2 bays of 30′ span each separated by 7′ piers for shingle excluder, in front of Head Sluice.	28′ + 20′ (breast wall)	22′ Clear width and 8′ foot paths on either side with provision of space for Railway Bridge	82 Lakhs Cft. of Concrete	366.92 Lakhs for words & 394.64 Lakhs including indirect charges.	5 Years.
Harike Barrage	Sutlej	6·5 Lakhs cusecs.	2087 ft.	22 bays of 60′ span each separated by 7′ piers for Regulator & 9 bays of 60′ span separated by 7′ piers for under sluices with 24′ divide wall and fish ladder.	19 ft.		69.68 Lakhs Cft. of Concrete & Masonry.	559.60 Lakhs for works and 603.34 Lakhs including all other direct and indirect charges.	3 Years.
Mayurakshi Barrage	Mayurakshi	2.9 Lakhs Cusecs.	1013 ft.	7 Spans of 60′ for Regulator and 8 spans of 60′ for under sluices.	13′-6″ for regulator and 16′-0″ for under sluices.				3 Years.
Kotah Barrage	Chambal	..	1970 ft.	10 Spans of 40 ft. each	40 ft.		23 Lakhs Cft. of Concrete and 27 lakhs Cft. of stone masonry	307 Lakhs including indirect Charges.	In progress

Aerial view of Barrage under construction from the Vijayawada hill with the existing anicut and canals on either flank.

by over 40 ft. in some places, after the installation of 6 ft. shutters as the anicut was not designed originally to withstand the pressures due to such shutters on top. Secondly, water has to be kept at a level of 8 ft. over the anicut for the increased ayacut, in the delta ; and it is found injurious to the anicut aprons to allow a spill of a column of 2 ft. of water over the top of the shutters, besides the huge waste of water which it involves. Thirdly, the existing anicut shutters can be tripped only by hydraulic arrangement, which is not quite a fool-proof. When the shutters fail to respond hydraulically, the plough must be brought on to the anicut. But the plough can remain on the anicut only if the water level is less than 7½ ft. over the anicut. Thus, if the flood level rises suddenly, and if the shutters do not respond to the hydraulic system, disaster to the anicut will be certain. It will not be safe to depend on such a precarious arrangement for an irrigation system of 11 lakhs of acres, and hence the need for a modern structure like a Barrage where the shutters can be operated from the top of the Bridge, even during high floods. Fourth reason is a very important one which was not made public lest it should create an unnecessary scare. After all those scours in the anicut were repaired in the summer of 1953, a small hole was noticed in the apron and when it was opened up, a huge hollow was noticed deep underneath the apron of the anicut. That gave a fright to the Engineers as the huge cavity was found to exist at a place where the apron apparently appeared to be sound on top. That hollow was promptly repaired. But the fear, however was there, that there might be more hollows of a similar nature underneath the anicut apron. We referred the problem to the Universities and Research Organisations ; and the Central Water & Power Commission's Research Station at Poona, who conducted experiments and declared that there were cavities in the anicut, but they could not locate where exactly they were and of what magnitude. Therefore, in the previous three years, special arrangements were made for vigilantly watching for any scours in the aprons. Elaborate arrangements were made for immediately tackling any scour that might be formed. Elaborate rules were laid down for disposing off the floods, concentrating the flows on the repaired sections of the anicut etc. Now that the Barrage is completed, there is no further cause for anxiety.

Advantages of the Krishna Barrage

The Krishna Barrage stabilises water supply to the existing 11 lakhs of acres in the delta, and there is no more anxiety about the damaged anicut and the precarious system for tripping and lifting anicut shutters. A higher water level can now be miantained in the river and more supplies pushed into the canals during the transplantation season, thereby completing the transplantation in the delta about 2 weeks earlier. This will be particularly beneficial to the low lying areas in the tail ends of the delta which are now transplanted late and get submerged during rains. Incidentally Krishna Barrage will help to bring another one lakh of acres into irrigation. For want of funds all the auxiliary schemes required for bringing one lakh of acres into cultivation were not executed. But about 40 thousand acres have already been brought into cultivation by the schemes so far executed and by taking some temporary measures in the delta, such as allowing new pipes in canal bunds, digging of new channels by the ryots, etc. Government have since allotted extra funds for expediting the Krishna Barrage Localisation Schemes.

Another advantage of the Krishna Barrage is to have a road bridge which is most essential because it is on the National Highway between Madras and Calcutta. Traffic on the anicut is now possible only for about 5 months in the year. The extra cost on account of adding Bridge to the Barrage is only about Rs. 55 lakhs against the cost of independent Bridge of about Rs. 80 lakhs which was actually proposed to be constructed by the Highways Department below the Railway Bridge. This portion of the cost of the Bridge viz. Rs 55 lakhs is being met by the Government of India from National Highways Funds.

Progress in the construction of masonry piers.

The Barrage is 3736 ft. long. It retains water to a depth of 20 ft. above the bed level of the river. It has 70 vents of 40 ft. spans in which 12 ft. high regulator shutters will operate to regulate the floods in the river and the flow of the water in the canals. A water level of 10 ft. above the present anicut level can be maintained as against 6 ft. at present. The roadway over the Barrage is 24 ft. wide with 2 footpaths 5 ft. wide on either side for pedestrain traffic. The work utilised 10,000 tons of steel and 50,000 tons of cement. It has 7 millions cubic feet of concrete and masonry and 900 numbers reinforced concrete wells.

Special Difficulties in the Execution

The work could be done only during the non-flood season (i.e. for 6 months in the year between December and May). During this period a Coffer dam of about 25 ft. height had to be formed in the river bed above the anicut, the entire water inside the Coffer dam area had to be pumped out and the work in the foundations done under great risk. The Coffer dam would be washed away in the next floods and it had to be formed again in the next working season. Even during the working season, there was always the danger of damage due to flash floods. Actually the Coffer dam breached in two years. But by prompt evacuation of people within two minutes' time, loss of life or damage to machinery was avoided. To ensure safety, a steel sheet pile Coffer dam was designed originally. But inspite of best efforts, sufficient steel piles could be obtained only for a part of the Coffer dam. In the last two years work had to be done by forming mere earth Coffer dam, as otherwise the work would have to be postponed by one or two years pending receipt of the steel sheet piles. It was a great risk because a breach in the Coffer dam would jeopardize lives of about 6000 people working in the pit. It may be noted that the earthen Coffer dam had to be formed by depositing earth through 20 ft. depth of water on rather slushy material at the bottom of the river; hence the tendency for sudden slips and breaches in the earthen bund. But after taking elaborate precautions such as keeping always ready steamers with punts full of earth, stones, and sand bags etc. and working out in minute detail a system of alarm, evacuation etc. the work could be completed without steel sheet piles.

Assembly of Barrage gate in P.W.D. workshops.

Other difficulties

Inadequate supplies of iron and steel; presence of huge boulders even at great depths below the river bed presumably deposited at the time of construction of the anicut 100 years back. The boulders made well sinking very difficult and slow. When the construction of the Barrage work was taken up it was proposed to reduce the water level in the river below the anicut crest level. But the Government subsequently decided to grow second crop paddy in the Krishna delta with Tungabhadra Reservoir Waters. This required maintenance of water level 3½ ft. above the anicut, which added appreciably to the difficulties in execution.

In a work of this magnitude there should have been many accidents. It is however, a matter of great satisfaction that there were only 3 casualities which is due to the special emphasis laid on safety measures.

Connected with this Krishna Barrage is the Skew Bridge across the Krishna Western Main Canal consisting of 2 spans of 120 ft. each. It was completed in a record time of 5 months without reducing the water level in the canal as water was required for the second crop irrigation and navigation. Novel methods were adopted in this construction; e.g. form work for the super-structure of bow string girders was started simultaneously along with the sinking of foundation wells, so that by the time form work was completed and reinforcement laid in position, the sinking of wells was completed and abutments and piers were built up to the required level.

Another important item in this project is Barrage Gates. The manufacture of barrage gates is being done in the new Public Works Department Workshops built on Sitanagaram side of the Krishna Barrage. The total weight of the gates manufactured is 2000 tons and the cost of manufacture is Rs. 150 per sq. ft. including cost of gearing equipment, hoist motors etc. This resulted in considerable economy which would not have been realised if the shutters were purchased from outside. Credit for the design of the Barrage gates entirely goes to the Krishna Barrage staff under the personal guidance of Sri Venkatakrishna Iyyar, Special Chief Engineer, Andhra Pradesh.

Continued on page 18

longevity

Pipe mains conveying water and distributing gas, providing sanitary services and carrying oil, are the lifelines of civilisation.
Today the Cast Iron Pipe, with Spigot and Socket Joints, provides the most widely used medium for the transmission of water and gas.

Manufactured to British Standard Specifications.

THE INDIAN IRON & STEEL CO., LTD.

Managing Agents:

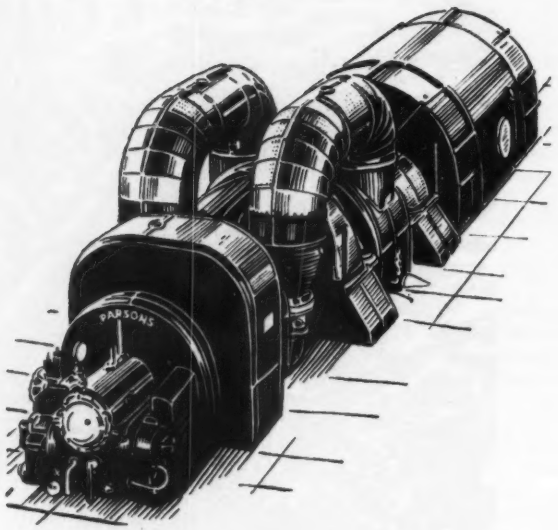
MARTIN BURN LTD. 12 Mission Row, Calcutta.

Branches: **New Delhi** **Bombay** **Kanpur**

IIX 48

C. A. PARSONS

100
120
200
300
and now
550 M.W. *STEAM TURBO-GENERATORS*



Machines of the sizes above and smaller ratings are under construction at the Heaton Works of C. A. Parsons & Co. Ltd.

The 550 M.W. set, which is to be installed at the new THORPE MARSH generating station of the Central Electricity Generating Board, will be the largest Steam Turbo-Generator in the world.

Agents in India

MARTIN BURN LTD.

Calcutta New Delhi Bombay Kanpur

MPCC-8

Thermal Power Stations

Civilisation has grown with the availability of surplus energy. Reduction of per capita energy consumption has always in the past led to a decline in civilisation and reversion to more primitive way of life. The chief sources of energy harnessed by man in the past, besides his own muscle power, were draught animals, wood, animal and farm refuse, wind and small waterfalls. In recent times, utilisation of fossil fuels and development of large hydro power have completely overshadowed these old sources of energy. Now nuclear power has emerged as a most promising and unlimited source of energy for future.

Energy is utilised in so many different forms. The most versatile form of energy is electricity. Uses and applications of electricity are very considerable. It is a basic commodity. As an industry, production of electricity is important next only to transport. Total production of electricity is an index of the country's industrial strength and prosperity In U.S.A. per capita consumption of electricity is about 3000 units per year. In U.K. and West Germany it is about half of this. In India it is only about 30 units per year.

Production of electricity all over the world is increasing by leaps and bounds. The present consumption of electricity is about 16 times than in 1920. In countries like U.S.A. and U.K., the production of electricity is doubled in every 8-10 years period. In India, during the first Five-Year Plan, the total installed capacity of power plant has increased from 2.3 million kilowatt to 3.4 million kilowatt, thereby raising the per capita consumption from 16 units to 25 units. In the Second Five Year Plan it is decided to double the installed capacity and raise the per capita consumption to 50 units. The rate of power development in the Third Plan is expected to be even higher than this. The U.S.S.R. is adding about 35 million kW power plant capacity during its current Five Year Plan, thus doubling its power output in five years.

It is estimated that about 4-6% increase in production of electricity results in one per cent increase in national income. Our current Five Year Plan provides an expenditure of about 435 crores on new electric projects and this amount plus the expenditure proposed on transport, will consume about 25% of the whole plan outlay.

By D. C. BHARDWAJ

Thermal Generation versus Hydro Electric and Nuclear Generation

Greater proportion of world's power requirements are obtained from thermal power stations using fossil fuels such as coal, oil and natural gas. This is due to the fact that coal is available in abundance in most of the countries and that steam power stations are low in first cost and they can be easily located in the load centres.

In India at the end of the first plan, out of the 3.4 million kW of installed capacity, nearly two-third was of thermal power During the last decade the addition of thermal power in India has been of the order of over one million kW and the hydro power addition has only been about half of this. This has been largely due to the serious shortage of power in the post-war period and the only way of meeting this shortage has been by installing more of thermal plants, which could be erected in a much shoter period than hydro plants. In the second plan, however, the addition of hydro capacity is envisaged to be 2.1 million kW and thermal 1.3 million kW. The larger hydro capacity in this plan period will mainly result from a number of large multipurpose projects in hand, the work on which was started in the first plan period.

India has abundance of both untapped hydro power sources as well as workable coal deposits. The hydro potential of the country is estimated to be about 35 million kWs of which only about 10% would be harnessed by the end of the Second Plan. The total workable coal deposits in India are estimated to be about 40,000 million tons. A very large proportion of these, however, is of low grade type. But the modern technological developments have enabled the successful utilisation of these coals for power generation. Our total rasing of coal by the end of the current plan will be about 60 million tons per year. We, therefore, have assured supply of coal for power generation for a long period.

India, being on the threshold of industrial revolution, requires vast development of her power industry. This can be achieved by exploiting both the hydro and coal resources. Some controversy seems to be going

on whether in the following plans more stress should be laid on hydro development or thermal generation. There is no doubt that cheaper power can be produced from hydro schemes due to non-existence of recurring fuel expense. There are also other advantage of hydro development, which are (*a*) reduced strain on the country's transport system, as coal deposits are largely concentrated in only two or three regions, while the hydro resources are better spread over the whole country, (*b*) capital investment in development of coal mines would be reduced and (*c*) there would be a greater saving of foreign exchange, as the foreign exchange component of hydro power is Rs. 200 to 300 per kW installed as compared to Rs. 450 to 500 for a thermal plant. There are, however, other overriding considerations which would compel us to develop thermal power at a faster rate than hydro power. These considerations are as follows :—

(*a*) Although the hydro power resources are better distributed than the occurrence of coal, it is not generally possible to locate the industries near the source of power and, therefore, expensive transmission lines have to be provided with hydro electric stations. Some of the industries must be located near the occurrence of raw materials or in the proximity of market or where port facilities are available and in many such cases, due to very long distances involved, it is not economical to deliver hydro power to such industries. Thermal power, however, can be generated and delivered at the site of such industries.

(*b*) Capital outlay on thermal stations is much less than that on hydro electric schemes. The present day cost of large thermal stations in U.K. is between £50 to £60 per kW. On this basis the cost of such stations in India would be about Rs. 800/- per kW. The Thermal Station at Trombay is estimated to cost Rs. 788/- per kW. On the other hand the cost of most of the hydro electric stations in India has been about Rs. 1,500/- per kW or above. For the rapid expansion of country's economy, large finances beyond the country's resources would be required and, as a result, the funds available for power development would remain limited for a long time. The demand for power, apply as elsewhere, will always outstrip the available capacity and, therefore, to meet such demand with the limited finances availables recourse to thermal generation is inevitable.

(*c*) The time taken to erect a thermal station of 200/300 MW in U.K. and U. S. A. is about 3½ years at present. Such station in India therefore can be erected within 4 years. In the case of hydro electric, however, it takes 6-8 years to complete the scheme. Due to limited financing capacity of the States, no such large hydro scheme are included in the current Five-Year Plan, the benefit of which would not accrue during the plan period. This means that for the purpose of meeting the demand of additional power during the third plan, any large hydro electric schemes on which work may be started in the beginning of the third plan, will not be ready in time to meet that demand. Addition of thermal power, therefore, would be necessary to meet a greater portion of the demand of power supply in t he third plan.

(*d*) In the case of hydro electric schemes, greater part of the expenditure is incurred on civil works, which usually do not permit phasing of expenditure and, therefore, considerable capital outlay remains unremunerative for some years. The thermal stations are very flexible in this respect and expenditure and benefits can be phased and immediate remuneration on capital is possible.

(*e*) Very little time is required on planning of thermal stations. Prolonged investigations and planning are necessary for hydro electric schemes which add to the time required for completing the scheme.

(*f*) In many parts of the country, water power is seasonal and it is necessary to have complementary thermal power stations for such regions, as is the case with DVC, Bombay and Madras. Such complementary thermal stations are also very useful to meet the vagaries of monsoon and to firm up the capacity of hydro stations over a longer period during the year of below normal rainfall.

(*g*) The richest mineral bearing areas of India such as parts of Bengal, Bihar and Madhya Pradesh, where maximum immediate growth of industries is expected, are rather poorly situated in respect of hydro power, but are very fortunate in respect of coal occurrence and, therefore, to meet the demand for power in these regions as fast as it grows, installation of large thermal power stations at the pit heads will be necessary.

It is, therefore, obvious that large scale addition of thermal power during the next 10-15 years is inevitable. It is estimated that during the third Five-Year Plan, the additional power required would be of the order of 6.5 to 8 million kilowatt and of this about 60% would be thermal power.

As to nuclear generation, excellent progress has been made in U. K. in this direction. Coal supplies in U.K. are lagging behind the demand of the industry and, therefore, Britain has been obliged to develop this source of power ahead of the other advanced industrial countries, *viz.*, U. S. A., U. S. S. R. and Germany who are more fortunate in respect of availability of fossil fuels. Britain proposes to add about 6 million kW of atomic power by 1965.

A study of the economics of nuclear generation in India is being made by the Atomic Energy Department. In view of the very high cost of nuclear station, which at present would be about Rs. 2,500/- per kW in this country, it is doubtful if energy from this source can be produced is significant quantities economically. There are one or two regions in India which have limited hydro power and are situated at a great distance from coal fields and in these areas there is a possibility of the atomic power being competitive. But in view of the financial stringency and difficulty of foreign exchange, it may not be possible to develop substantially this source of energy even in such areas.

Unless some radical developments occur in the nuclear technology, that will bring down the capital cost of an atomic pile considerably, the generation of energy from this source in India, at least for the next 10 to 15 years, will remain considerably behind that from thermal and hydro stations.

Sizes of Units and Steam Conditions

During the last decade there has been a dramatic growth in the size of generating units, and in the adoption of high steam pressures and temperatures. The increase in the sizes of sets has resulted in reduction of capital cost per kW and adoption of higher steam conditions and reheat cycles have considerably improved the thermal efficiency. For given sizes of sets, increased steam conditions involve higher capital costs, but the overall result of bigger units with simplified arrangement on the unit system has resulted in considerable economy in capital as well a running costs.

In the immediate post-war period in U.K. the largest sets installed were of 30 to 60 MW capacity. The size of single shaft sets of higher capacity was restricted due to the carrying capacity of the British Railways being limited to 150 tons. The heaviest part of a Turbo Alternator from the transport angle is the alternator stator. With the advent of hydrogen cooling for the altenators, it was possible to increase the size of the sets to 100 MW capacity without increasing the weight of alternator stators. The subsequent development in the cooling of the rotor and stator by using hollow conductors has led to development of 200 and 275 MW tandem compound sets without increasing the weight of the stator. By cross compounding two 275 MW sets, it has been possible to plan a 550 MW unit.

How fast the smaller set is becoming out of date can be judged from the fact that during 1956, out of the total number of 38 new sets commissioned in the British Power Stations, 1 set was of 100 MW, 24 of 60 MW, 12 of 30 MW and 1 of 20 MW. The trend towards larger sets in U. K. is now an established fact and can be seen from the programme for commissioning new plant in 1961 approved by the C.E.A. in 1956. This includes 5 units of 200 MW, 6 of 120 MW, 1 of 100 MW and 4 of 60 MW. One 350 MW and a number of 275 MW sets are planned to be installed in 1962.

In U. S. A. the larger sets were employed much earlier than in U. K. as in that country the railways would accept loads of 230 tons. While in U. K. the largest sets in operation at present are not more than 100 MW, machines of 100 MW-220 MW are standard in U. S. A. The average size of a turbo-alternator set supplied by one of the biggest manufacturers in U. S. A. in 1947 was 38 MW. In 1957 the same manufacturer supplied an average size of 156 MW set which shows an average increase of 15% a year. The largest unit in service is 260 MW and 325 and 450 MW sets are under construction.

In U.S.S. R. 50, 100 and 150 M.W. sets are standard. There are thirty-five 100 MW and two 150 MW sets in service. A 300 MW set is being designed and a 500 MW set is being thought of.

In India a 50 MW set was installed in Calcutta in 1950. Then 3 sets of 50/58 MW capacity were installed at Bokaro in 1953. Recently two 62.5 MW sets have been commissioned at Trombay. The largest sets so far planned for istallation in this country appear to be the two units for Durgapore Thermal Station of DVC. These are 75/82.5 MW sets. There is no reason why in the third plan sets of 120 and 200 MW capacity should not be installed in this country.

In the case of turbines, the limiting factor in increasing the unit size was the area of the exhaust blading. This has been overcome by adopting multiple exhaust. Cross compounding enables much bigger units to be built than tandem compounding.

The size of the boiler units in 1920 was much smaller than that of the turbines. This necessitated a number of boilers per turbine. Since 1925 the size a boiler unit started increasing, mainly as a result of introduction of pulverised fuel firing. Boiler units as large as turbines have been in use in the post-war period and a common practice now-a-days is one boiler for one turbine.

The 30 and 60 MW sets installed in U. K. immediately in the postwar period were, with few exceptions, designed for 600 lbs./sq. in. and 850° F. steam conditions. By 1950 the steam conditions for 60 MW sets were increased to 900 lbs./sq, in. and 900° F. In 1954, a 100 MW set operating at 1500 lbs./sq. in. and 1050° F was commissioned, 120 MW reheat sets for 1500 lbs./sq. in. 1050° F was commissioned, 120 MW reheat sets for 1500 lbs./sq. in. and 1000° F and 200 MW reheat sets for 2300 lbs./sq. in. and 1050° F are under construction. The 120 MW set is to be commissioned in 1958. In the 275 and 550 MW sets same steam conditions of 2300 lbs./sq. and 1050° F are to be adopted. No installation at critical or super-critical pressures has been plannned in U. K. so far.

In U. S. A. the steam pressures of 2500 lbs./sq. in. and temperatures of 1050° F are common place. The highest stam temperature in use is 1100° F. Reheat sets are much more common in U. S.A. than in U. K. The reheat temperature is 50° F below that of the initial steam. Two 450 MW sets designed for operation at 3500 lbs,/sq. in. and 1050° F are expected to be commissioned in 1959. A 325 MW set designed to operate at 5000 lbs./sq. in. and 1200° F is under construction and will be installed at the projected Eddyston Station, Philadelphia.

In U. S. S. R. the 150 MW sets operate at 2400 lbs./sq. in. and 1050° F and reheat to 977° F. Plant to operate at 3,057 lbs./sq.in. and 1076°F are under construction. An experimental plant operating at 4,266 lbs./sq. in. and 1112° F has been successfully tried.

In India, by 1950 the highest steam conditions in use were those at Cossipore Generating Station of the Calcutta Electric Supply Corporation. These were 600 lbs./sq. in, and 850° F. Later, Bokaro adopted 900 lbs./sq. in. and 900° F. The highest pressure and temperature in use in this country at present are those at Trombay Thermal Station. These are 1250 lbs./sq. in. and 950° F. The plant for Durgapore will work at 1500 lbs./sq. in and 1005° F.

Higher steam conditions have led to higher thermal efficiency. In these days of rising costs of fuels, it has,

therefore, become necessary to pursue the higher pressures and temperatures. In order to utilize the higher steam pressures and temperatures to maximum advantage, it is necessary to use larger turbines and there exists a direct relationship between the two. The larger units more than offset the extra cost involved in designing plant suitable for higher pressures and temperatures. The effect of increase in plant size and in steam conditions is demonstrated in Table I which gives the estimated efficiencies and cost per kW installed in the British Power Stations on the basis of prices ruling in the beginning of 1957.

Table I.

Unit size	*Inlet conditions*		*Exhaust condition*	*Thermal Efficiency*		*Cost per kW*
MW	psi	°F	M.Vac.	Optimum %	Av. annual %	£
30	600	850	28.8	27.4	25.5	75.5
60	900	900	28.8	30.8	28.0	61.9
100	1500	1050	28.9	33.4	30.5	57.9
100 reheat	1500	975/950	28.9	34.4	31.0	54.7
120 reheat	1500	1000/1000	28.9	35.1	32.0	54.2
200 reheat	2350	1050/1000	28.9	37.0	33.5	50.0

From the Table I it is obvious that with larger sets there is a considerable gain in the thermal efficiency of the plant and in the initial cost per kW installed. It also shows that reheat installations are not costlier to build than the straight steam cycle plants.

For sets larger than 200 MW the gain in cost and efficiency is not so marked. In fact the 550 MW set being planned by C. E. A. to be commissioned in 1963 will give only about ½% gain in thermal efficiency over the 275 MW set and saving in the capital cost per MW will be only marginal. Such a large set is more of a prestige design than an economic proposition, as by concentrating large capacity in one unit the loss of flexibility in operation outweighs the nominal gain in cost and efficiency.

The gain in efficiency from the very large sets appears to be substantial when super-critical pressures and very high temperatures are adopted, as is being planned in U. S. A. Such sets adopt double reheat cycle. The 325 MW set under construction which is to operate at 5000 lbs./sq. in. and 1200° F has an estimated thermal efficiency of 42.5%.

Tatas' Trombay Thermal Station in India has been designed to give a thermal efficiency of 29.1%.

The actual highest efficiency achieved in U. K. so far is 31.53% at Castle Donington. The average efficiency of all the British stations during the year ending March, 1957 has been 24.93%. In U. S. A. the highest efficiency achieved so far is 37.8%.

It is important to recognise the difference between thermal efficiency and economic efficiency. The maximum thermal efficiency does not necessarily represent the maximum economic efficiency. What is really important in practice is the economic or cost efficiency. Thermal efficiency cuts down the fuel cost, which is only one component of the total cost of generation of electricity. Higher efficiency achieved at the expense of reliability and flexibility in operation may increase the overall cost of generation due to reduced availability of plant. Thermal efficiency is not so important in the case of plants working one or two shifts only or which are used to firm up a seasonal hydro power as it is with base-load plants.

Interconnection of Generating Stations

The extensive development of power industry in the world and the lower rate of increase in the cost of electricity than the general rise of prices of other commodities has been largely achieved by interconnecting the power stations into large common networks. The 262 Power Stations of the Central Electricity Authority in U. K. are integrated into one huge interconnected system and no station operates in isolation or as a separate entity. In U. S. A. similar large interconnected system have been developed by the public utilities. The T. V. A.'s interconnected system includes 45 hydro plants and 14 steam plants having an aggregate installed capacity of 9.28 million kW and on this system electricity is generated at the following rates :—

From hydro stations at 1.06 mills/kWh (about .5 np).

From thermal stations at 2.66 mills/kWh (about 1.25 np).

From the system as a whole at 2.44 mills/kWh (about 1.15 np).

The advantages of interconnection are as follows :—

(*a*) In isolated stations spare plant capacity has to be provided at least equal to the largest set in use. This involves considerable investment of capital in spare capacity for which reason it is not always possible to employ very large sets in such stations and thereby advantages of low cost per kW installed and higher efficiency resulting from larger sets is not possible. Pooling of the spare capacity in an interconnected system results in a considerable saving in the capital cost of the generating plant and permits the use of larger sets.

(*b*) Owing to diversity of maximum demands in different areas, the total generating capacity required to meet the overall maximum demand in an interconnected system is less than that required with isolated stations

(*c*) The outage of any one unit in a station in a large interconnected system at any time is covered by a relatively small standby capacity in a number of other power stations. This permits freedom in the design of the plant as it is no

longer necessary to take precaution against every type of trouble. This aspect of interconnection coupled with the improved availability of the boiler plant has led to the adoption of unit system of boilers and turbines, which simplifies station design and brings down costs considerably in high pressure installations.

(*d*) In an integrated system plants having the lowest fuel costs per unit generated can be operated as base load units and those with higher fuel costs per unit are run at peak load and thereby considerable economy in fuel costs is effected. With this method of operation, the plants of the highest available efficiency can be located at sites where the fuel costs are lowest and thus maximum economic generation of electricity can be obtained.

(*e*) Where hydro power is seasonal, interconnection with steam stations permits of running the hydro plants to take up base load and the steam plants to take up peak loads during the rainy season and *vice versa* in the dry season. This enables the best utilisation of seasonal water power.

Development of regional grids in India will facilitate interconnection of power stations and this will enable economical generation of power. Development of nuclear power in India will also be facilitated by creating integrated systems, as, for economic generation, nuclear station must be operated on a high load factor and this would be possible by operating same to take the base load of a large integrated system.

Siting

The choice of site for a large thermal station is not an easy matter. In order to keep down the cost of transmission system the station should be located near the load centre. Where coal fields are not very far off, it may be economical to locate the power station in the coal fields, especially if the coal is of poor quality or middlings from coal washeries are to be used. With this arrangement, cost involved in the transmission lines can be off-set by the saving effected in the haulage of coal containing high quantity of ash and moisture. The existing thermal stations at Bokaro and Khaper Kheda and the proposed stations at Durgapur, Korba and Neyveli in the South are examples of this type.

Power Stations require abundant quantity of cooling water of good quality and facilities for the delivery of machinery and fuel. In U. S. A. the power stations are installed on the banks of large navigable rivers and the coal supplies are effected by ships or barges. In U. K. the stations are located on the sea-side, on estuaries or on river banks, and the coal supplies are sea-borne or rail-borne and in some cases are both sea-borne and rail-borne. On certain rivers enough cooling water is not available and in such cases cooling towers are provided.

In India most of the stations are inland and are located on river banks. In some of the rivers the flow of water during dry weather is not enough and, therefore, cooling towers are provided in such cases.

Disposal of ashes is a great problem in case of thermal power stations. This aspect should be given careful consideration at the time of selecting site for the station. Availability of large tract of waste lands suitable for dumping of ashes at a distance not far away from the power station will facilitate quick and economical disposal of ashes.

The ground on which the power station building is to be located should have a level contour and should have subsoil which can support reasonable loading so that foundation costs can be kept low.

Layout

The power generated in large thermal stations is generally transmitted to load centres through extra high tension circuits. The generators are normally designed to generate power at 11 to 20 kV. and they are directly connected to transformers which step up the voltage to 66, 110, 132, 220 or 330 kV. All switching is arranged on the e.h.t. side.

The step up transformers are arranged in the outside along the turbine house. The e.h.t. switchgear and associated circuit leads are all outdoor type and are usually located on the open site beyond the transformers along the station building.

The boiler house and turbine house are arranged in parallel with an auxiliaries bay in between. The building is frequently symmetrical to a central axis and is divided into a number of bays. A compact and economical arrangement is obtained by installing the turbines transversely in the turbine house and by locating the boilers in the opposite bays in the boiler house. This arrangement involves a larger span for the turbine house crane but allows similar steam and feed water connections between all the boilers and turbines. This arrangement also permits the installation of turbo sets of twice the capacity in the same turbine house extension at a latter date by arranging the bigger sets longitudinally. The boiler size with the bigger sets, however, remains the same and two boilers per set are employed.

A loading bay at either end of the station or in the middle is provided. The coal bunkers may be located in the bay between the boiler house and turbine house or in the rear of the boiler house, *i.e.*, away from the turbine side. The first arrangement has been popular in the past, but this is giving way to the second arrangement in the case of high pressure reheat installations.

Chimney arrangement may be one small chimney per boiler, which is usually of steel and located at the top of the boiler or one or two large chimneys for all the boilers and these are located outside the boiler house and are usually very high (200-400 ft.) and built in reinforced cement concrete. The former arrangement is popular in U .S. A. and Germany and the latter arrangement is followed in U. K., where it appears to have been adopted to meet the requirements of legislation to prevent fouling of the atmosphere.

The dust extraction plant and induced draft fans have to be located to suit the chimney arrangement. In the case of small chimneys fitted on the top of boilers they are located inside the boiler house on the rear of the boiler plant where the coal bunkers are between the turbine house and boiler house, otherwise

above the boiler plant where the bunkers are at the rear of the boilers. In the case of the chimneys located outside, the dust extraction plant and the I. D. fans are also located outside.

The turbine and boiler basements are usually at the ground level and the operating floor for turbines and boilers is at the same level about 25′ to 30′ above the basement. Common control centres for two boilers and two turbines are located at the operating floor between the boiler house and turbine house. The electrical control room for the entire plant is usually located outside the turbine house on the switchyard side, as this arrangement keeps down the cost of cabling. The offices for the operating staff are sometimes located above the electrical Control Room.

The administrative blocks and stores room, etc., are located on one side of the station.

The cooling water pumps are usually located at the source of water in the case of cooling by sea or river water and may be inside the turbine house in the case of cooling by cooling towers.

The coal handling plant is usually located in the open site on the side of the boiler house. The coal storage is done in the open in huge piles. The coal to the bunkers is carried by conveyors entering the bunker bay either from the side of the station or from the middle.

Buildings

The conventional power station building consists of a steel frame structure clad in brick masonry. For economy's sake in some cases the wall cladding is done with corrugated asbestos or iron sheets and patent glazing. The latter type of cladding is not satisfactory for hot climates such as in India. Roof decking frequently adopted consists of corrugated aluminium alloy sheeting covered with insulating and water proofing material.

For reason of economy the boiler supporting structure is now being integrated into the boiler house steel work and the boilers are suspended from the roof.

For effecting economy in the use of steel, recent trend is to use R. C. C. structure upto the operating floor which includes most of the heavy load bearing members and steel is used only for part of the building above the operating floor where sections are comparatively smaller in size and lighter in weight.

Complete R. C. C. structure for power station building has been successfully adopted in many places. In some of the British Power Stations the turbine house building consists of R. C. C. frame and barrel vaulted type of roof only $2\frac{1}{2}$″ thick.

By providing wall panelling of precast R. C. C. slabs in an all R. C. C. building a very pleasing appearance is obtained. Moreover, such a construction is cheaper than the steel frame building. In view of the serious shortage of steel and foreign exchange, such a building is most suitable for power stations in India. The only point to be kept in view in adopting a R. C. C. building is that it is economical to construct the whole building for the ultimate capacity of the station in one stage, as one of the major item of expense involved in this construction is that of shuttering which has to be specially prepared for the shell or barrel vaulted type of roof.

In some of the British Power Stations coloured cement has been used for the chimneys and cooling towers to match their appearance with the power station building wall made of coloured bricks.

Considerable economy in the building space per kW installed has been effected by the adoption of unit system of turbine and boilers. A station comprising 60 MW. sets with multiple p. f. fired boilers would require about 58 cu. ft. of building space per kW. installed compared to 33 cu. ft./kW for the same size of sets with unit boilers. Figures representative of British Power Station design practice are given in Table II.

TABLE II

Unit	*Station Size*		*Boiler House*		*Turbine House*		*Station*	
Size MW.	*Sets MW.*	*Boilers Klb/hr.*	*cu. ft kW.*	*sq. ft. kW.*	*cu. ft. kW.*	*sq. ft. kW.*	*cu. ft. k.W*	*sq. ft. kW.*
30.	6×30	6×330	24.3	2.06	15.1	.250	39.4	.456
60.	8×60	8×550	19.8	.174	13.4	.176	33.2	.350
120.	5×120	5×860	16.0	..135	12.9	.159	28.9	.294
200.	5×200	5×1400	16.7	.121	11.1	.123	27.8	.244

Continued on page 18

Bin-el-Ouidane Hydro-Electric Power Station, Morocco

By GALLETOUT and BERGOUGNAN

Lying under the High Atlas Mountains, the Bin-el-Ouidane dam constitutes the starting point for the power harnessing of the Oued-el-Abid. The main purposes of this power harnessing are :

—irrigation of vast plains lying at the confines of the Atlas and Oum er Rebia.

—the recuperation of a yearly energy amounting to 500 millions kW-hours.

This vast program now in process of completion includes the construction of several works executed by the Energie Electrique du Maroc.

The Oued-el-Abid, main tributary of the Oum er Rebia, receives its most important quantity of water from the Oued Ahansal, some miles above the Bin-El-Ouidane dam. The construction of this work includes a slight vault as it was possible to rest on two calcareous rocks which narrow the Oued bed at a right angle with the dam.

The main characteristics of the dam are the following :

—total height above foundations.....135 m
—depth of the foundations under the Oued 25 m
—length at the dam crest..... 260 m

The width at bottom is 32 m ; on the crest a road connects the Bin-el-Ouidane, a village entirely built by the Energie Electrique du Maroc for the needs on site, to the Azilal locality.

Thanks to the dam it is possible to create a huge reservoir of 1,500,000,000, cubic/meters out of which 1,000,000,000 are available for the production of electrical energy. The dam is fed from a catchment area covering an area of about 3,800 ha, that is the equivalent of the surface of the Annecy lake.

On the right river-bank a ski jump type spillway allows of discharging in the Oued down the stream a delivery of 2,500 cubic meters/sec, corresponding to the supposed maximum flood. Two sluice valves placed on the same river at the dam bottom part allow of the emptying of the reservoir if necessary.

The power station built at the dam bottom part includes three turbo-generator sets of a 135,000 kVA total power, transmitting their energy towards the Afourer distribution station.

Some miles downstream of Bin-el-Ouidane, the turbined water is recovered in the Ait Ouarda reservoir of 2,500,000 cubic meter useful reserve. This dam allows of compensating the Bin-el-Ouidane flow and also of diverting the Oued waters into an underground level.

This 10.5 km long deviation runs across the Tazerkount mountain mass along a tunnel and opens on to a surge tank situated at the place called Talaat N'Tadout. From there leave two penstocks leading to the Afourer power-station, where the water is again used under a 225 m head in order to feed two turbo-generator sets of a 104,000 kVA total power. One third penstock allows, when necessary, of being used as waste channel and permits a constant delivery downstream of about 25 cubic meter/sec to be obtained.

On flowing out of the Afourer power plant, the waters are recuperated in a reservoir and distributed among two East and West canals for the irrigation of the 115,000 ha of the Beni Moussa and El Kelaa plains of the Sharnas and lastly rejoining the Oum er Rebia.

The Oued el Abid, thus graded and diverted from its normal course, allows of obtaining an average delivery of 26 cubic meter/sec. indispensable for irrigation purposes.

The yearly 500 millions kW hour supplied by the two Bin-el-Ouidane and Afourer power stations are transmitted from the Afourer station to the distributions stations of Tit Mellil, near Casablanca and El Ouali near Fez.

The Bin-El-Ouidane Power Station

The execution of engineering work, dam and works were entrusted to the consortium including the following firms: SOCIETE GENERALE d'ENTREPRISE et ENTREPRISE FOUGEROLLE, Entreprise de Construction du Barrage de Bin-el-Ouidane.

View showing the floors in the power station

The intake gates of the waste channel have been built by the SOCIETE BOUCHAYER VIALLET.

The trash-racks, low head gates at the beginning of penstocks and the control organs for sluice-valves were executed by the SOCIETE NEYRIC-PORTUGAL.

THE SOCIETE DES FORGES ET ATELIERS DU CREUSOT (Schneider Works) have built the butterfly valves, spiral casings and the three turbines with their regulating sets.

The Company LE MATERIEL ELECTRIQUE S-W has built the three generators and also the thrust-bearings and the voltage regulation.

Each generator is directly connected to a 8500/150,000 V transformer supplied by SECHERON-Geneva.

The 150 kV outgoing equipment placed between the power station and the dam, as well as the electrical equipment of the power station have been executed by the Cie GENERALE D'ENTREPRISES ELECTRIQUES.

The power station has been rendered entirely autonomous by installing two auxiliary sets — horizontal Francis turbine — generator — of a 400 kVA unitary power at 1000 r.p. m. ensuring the feeding of all auxiliary services in the power station.

The turbines of these auxiliary sets as well as regulators are of the NEYRIC-AFRIQUE construction, the generators being constructed by LE MATERIEL ELECTRIQUE S-W.

The mounting work inside the power station has been executed by means of two 200 tons and 15 tons travelling-cranes, manufactured and installed by the SOCIETE APPLEVAGE.

Lastly, the SOCIETE LE MATERIEL ELECTRIQUE S-W has supplied two pumping sets required for the emptying of casings and aspirators and the exhausting of leakages.

The coordination for the designing of the whole work has been ensured by the SOCIETE D'ETUDES ELECTRIQUES ET HYDRAULIQUES DU MAROC, Consultant Engineers of the Energie-Electrique du Maroc.

A. C. Generators

Generating Sets

Each of the main generating sets, three of which are in service, is constituted by a vertical shaft assembly including at its bottom part, a turbine of the Francis type with its guide-bearing, then the generator with its two guide-bearings and thrust-bearing, lastly the main and pilot exciters of the generator and at last a pilot generator for the feeding of the turbine regulator motor.

The generator is supported by a metal casing resting on a crown forming one part with the turbine spiral casing, so as to obtain a uniform distribution of the loads on the set foundations.

Each turbine is fed by a steel sheet conduit of a 3.80 meters diameter and about 55 m length embedded in the dam concrete. Each penstock is at its head provided with a sluice valve capable of cutting down the maximum flow and having an entrance gate placed before.

The main characteristics of each turbine are as follows:

The static head is comprised between 105.6 m and 61 m, the effective head varies between 105 m and 59 m.

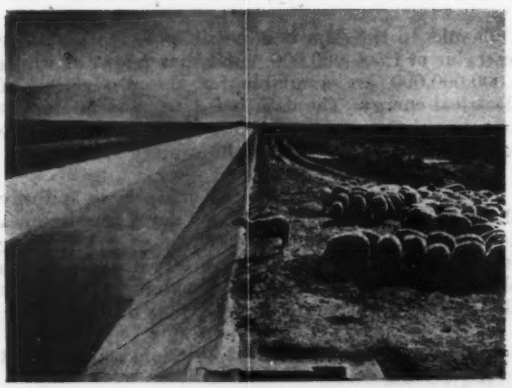
Delivery: 52 cubic meter/sec under 89 meter head.

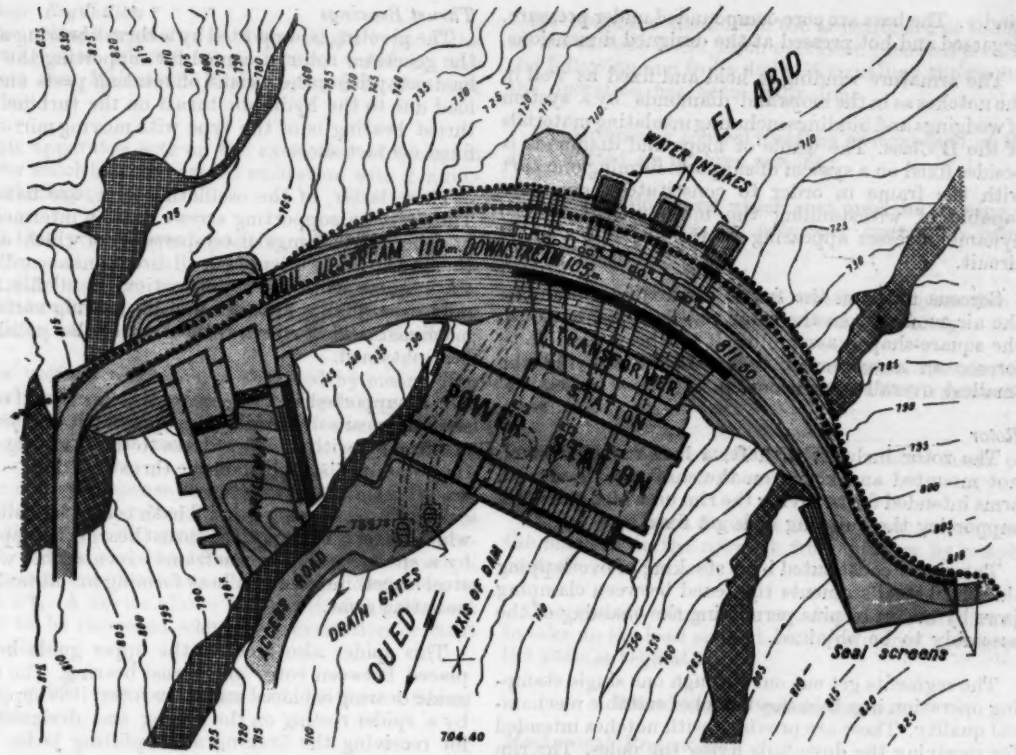
Nominal running: 250 r.p.m.

Runaway speed : 500 r.p.m.

Maximum power : 56000 hp.

Partial view of main canal D





Plane view of dam and power station

Maximum efficiency for 89 m of effective load.

According to their design and construction the generators are akin to a classical technique which has stood the test of time, specially in France at the power stations of l'Aigle and Genissiat. They are entirely closed, self-ventilated and provided with air coolers.

The main characteristics of each generator are the following:

Nominal power at continuous running 45,000 kVA

Power factor : 0.9

Voltage between phases : 8,500 V

Frequency : 50 cycles..

Limits of voltage regulation : $\pm 10\%$

Synchronous velocity : 250 r.p.m.

Runaway speed : 500 r.p.m.

Rotor moment of inertia : 1700 TM_2.

Capacity for absorbing reactive current under 8,500 V between phases with a residual excitation equal to 10% of that necessary for obtaining 8,500 V between phases at no-load and normal speed : 45,000 kVAR.

Short-circuit ratio : 1.6.

Stator

The stator includes a frame in two parts of welded steel sheet, forming a rigid assembly after the joining together of the two parts. It is designed for receiving the magnetic circuit stacked on round pins forming one part with the frame and bearing the arm supporting the thrust bearing, and also opposing the resulting stresses and transmitting them to the casing.

The magnetic circuit itself is made of an entangled stacking of magnetic sheet segments of high quality, stamped and notched by one single punching operation. The packet of stampings in which are provided the ventilating ducts, is solidly tightened between the clamping jaws.

End cross pieces of magnetic steel provided with fingers transmit one part of the tightning stress to the teeth of the stackings of stampings.

The stacking of the magnetic circuit is executed at the power station itself, which allows of obtaining an homogenous packet of stackings without joints affording the maximum safety owing to its mechanical qualities of resistance to the thermal dialation stresses and the vibrations which may appear while running.

In the notches of the magnetic circuit is placed the armature winding, of the lozenge imbricated type, with two conductors in each notch. The total conductor is subdivided into elementary conductors lapped with impregnated asbestos, changed over inside the notch according to the Roebel type in order to reduce to the minimum the importance of eddy currents.

The earth insulation is constituted by a taping with several layers lapped with mica tape with asphalt

binder. The bars are core compounded under pressure, degassed and hot pressed at the designed dimensions.

The armature winding is held and fixed as well in the notches as in the loops and diamonds by a system of wedgings and bindings including insulating materials of the B Class. The whole of loops and diamonds is besides fixed on a system of supports forming one part with the frame in order to constitute a structure capable of withstanding the most violent electro dynamic stresses appearing at the time of a short circuit.

Screens fixed on the frame ensure the guiding of the air coming from the rotor ventilators. Thanks to the square-shaped assembling it has been possible to foresee an arrangement of air coolers having the smallest overall dimensions.

Rotor

The rotor includes a shaft, a hub moulded steel, hot mounted and keyed on the shaft provided with arms intended for receiving the rim on which the poles supporting the inducing coils get fixed.

The rim is constituted by a stacking of overlapping thin sheet steel segments tightened between clamping jaws by means of pins permitting the chaining of the assembly to be obtained.

The segments get cut out through one single stamping operation in a thin sheet steel of suitable mechanical quality. These are provided with notches intended for receiving the dove-tails fixing the poles. The rim gets built on site in the power station; once built, it gets hot keyed on its hub.

The poles are constituted by a stacking of cut out thin steel sheets, tightened by pins between tightening jaws. The cut out outline embraces the shoe pole, the pole piece and dovetails, the auxiliary punchings are obtained by the same operation.

Each pole is fixed on the rim by two dovetails, the pole piece is provided with an axial slot ensuring a certain flexibility when keying the dovetails and allowing of a suitable distribution of stresses.

Round notches in the pole piece are intended for receiving the damping devices . The pole clamping jaws, of high resistance forged steel ensure the holding of the front parts of the inducing coils.

The inducing coils are made of copper tape wound on edge, the turns are insulated from one another by means of shellacked asbestos sheets, hot pressed so as to obtain a block that will not lose its shape.

Wedges between poles ensure the lateral holding of the coils by opposing the action of the tangential component of the centrifugal force.

Springs placed under the coils permanently secure these against the pole shoes and oppose any displacements or vibrations of the inducing winding.

The rotor is provided with two ventilators on each side of the active part ensuring the air movement inside the closed enclosure. On the hub arms, at the rotor bottom part is placed a braking rim upon which act the braking and upraising jacks.

Thrust Bearings

The pivoting is supported by a thrust bearing above the generator rotor, designed for supporting the total load comprising the weight of rotating parts and the load due to the hydraulic thrust on the turbine. The thrust bearing is of the type with moving mirror and fixed contact shoes.

These latter, of the oscillating type, are babitted. They rest on supporting screws by the intermediary of spherical bushings of tempered steel which allows them to be freely oriented in all directions according to the requirements of the formation of oil film. The mirror is of alloyed steel and its bearing surface is machined and finished until the specular polish has been obtained.

It is supported by a moving crown fixed itself on the shaft by means of bending bars applying it on a journal of the shaft with a higher stress to that existing when the total load is applied on the thrust bearing.

The thrust bearing is in oil bath cooled by coils into which water is running. The thrust bearing is supported by a spider resting in the frame executed in welded steel sheet including a boss forming an oil tank and radiating arms.

This spider also receives the upper guide bearing placed between rotor and thrust bearing. The under guide bearing is placed under the rotor; it is supported by a spider resting on the casing and designed also for receiving the braking and uplifting jacks.

The two guide bearings are of the type with babitted oscillating shoes, and oil bath cooled by coils into which flows the cooling water.

Coolers, Braking and Upraising

The air coolers are placed in the casing corners whose inside partitioning is intended for leading the hot air in their direction. The cooled air is then distributed to the upper ventilator and the lower ventilator.

The dimensioning of the coolers is reduced so as to reduce to the minimum the load losses resulting from their presence in the air circuit of the machine. They are constituted by bundles of copper tubes, gilled, flanged over plates forming the bottom of a water box. Each tube can be easily dismounted and replaced, cleaning can be easily done.

The uplifting jacks are also used as braking jacks. These jacks can be fed either from a high pressure set for the lifting or by the oil under pressure of the air accumulators of the turbine.

At the time of stoppage of the set, the braking takes place when the speed reaches 30 to 40% of the nominal speed. The lifting is done before each starting in order to insert an oil film between the rubbing-surfaces of the pivot, to avoid any risk of jamming at starting.

Excitation

The main and pilot exciters as well as the pilot generator are placed above the pivot of the set, on a separated shaft connected with the main shaft by means of an elastic coupling and guided on its upper part by a guide-bearing in oil bath and natural cooling.

Voltage Regulation

The voltage regulator is of the BJ 30 type of the Westinghouse Electric Corporation, built by the Societe LE MATERIEL ELECTRIQUE S-W (Puteaux Works).

This apparatus acts on the excitation of the main exciter which has a separated excitation with 2 inducing windings:

(*a*) One preponderant positive winding.

(*b*) One negative winding allowing of annuling the residual inducing field and also providing a negative impulsion at the time of an overvoltage or fault.

The voltage regulation is obtained by means of a normal response device for $\pm 0.5\%$ regulating voltage variations and a quick response device in case where voltage regulations exceed $\pm 5\%$.

The normal response device acts on the main rheostat motor through more or less long and rapid impulses according to the difference between the generator terminal voltage and the reference voltage to reach a continuous impulse when the voltage deviation is about 5%. A device allows the speed of the rheostat motor to be increased when a desexcitation or fault takes place.

The quick response device includes two different systems:

(*a*) A device for normal impulses comprising contactors inserting or short-circuiting one part or the total of resistances foreseen on the inducing circuit of the main exciter according as we have a quick desexcitation or quick excitation. Besides one contactor allows of giving a negative impuse by short-circuiting one part of the resistance placed in series with the negative winding.

(*b*) A device of reinfored impulses which in addition to the above working, allows in the case of a quick excitation to suppress the influence of the negative winding.

The contactors and various above circuits are acted by a master element including mainly a coil fed under a rectified voltage proportional to the generator voltage. This coil determines the position of a moving arm including the normal and quick response contacts.

Thanks to the voltage regulator, the following conditions can be satisfied.

(*a*) Stability of generator voltage at no load for regulating voltages comprised between + or —10% of U_n.

(*b*) Quickness of response suitable for the voltage perturbances when the set is connected with the network.

Working of the Sets

Three control systems have been foreseen by the ENERGIE ELECTRIQUE DU MAROC. They are as follows :

(*a*) Manual control from the switchboard of the set on the turbine floor. Each operation executed permits the following one to be done. A signalling shows that the operation has been really done.

(*b*) Automatic control from the switchboard of the set, splitted up in three periods :

—Hydraulic period which goes until the opening of the butterfly valve, all accessory operations being done.

—Electric period during which the generator is automatically placed under speed and voltage.

The operator had to press on two control buttons, the 3rd period being that of the coupling which is manually obtained.

(*c*) Automatic control from the control room on which we find the 3 above periods.

It has also been foreseen in that case to connect the machine to the network from Afourer by remote control.

One remote control is also foreseen from Afourer to take up the load and act on the reference voltage of the voltage regulator.

Protections of generating sets

Mechanical Protections

One M.E.C.I. recording-device controls the temperature of the bearings, pivot and stator. A signalling is provided for in case of a bearing or pivot abnormal temperature.

Thermostats placed in the bearings and the pivot allow the set to be stopped in case of dangerous temperature.

Electric Protections

1° Longitudinal differential protection : causes the stopping of the set, the quick desexcitation and the sending of CO_2 in the machine.

2° Stator mass with a device for the rectifying of the neutral point: causes stoppage and quick desexcitation.

3° Maximum current.

4° Maximum voltage.

5° Current return.

6° Unbalance protection.

7° Rotor mass.

Control and release are operated by thermostats placed in the hot air and fresh air in the machine.

On the other hand, a protection against fire is executed by Tecalemit. The CO_2 battery can be operated either by the differential protection or by thermostats placed in various points of the generator or by a detection system whose principle is based on temperature unbalances on various points of the machine.

In addition the transformers are protected by means of a tank protection and the Buchholz protection.

Continued from page 2

Electric Supply Industry and the role of Private Sector

too welcome. For instance, if some one comes forward with proposals to proceed with the Sharavati project—an important project with a power potential of 800,000 kW—the State's responsibility would be reduced to that extent.

I can assure you of one thing, namely that there has been an atmosphere of defeatism and despondency in the private sector, particularly because sometimes they feel that the emphasis is more and more on the public sector. The fact that we have adopted a socialistic pattern of society should not cause any worry. The ultimate aim is that there must be prosperity and particularly industrial prosperity in the country. If by helping the Private Sector we can achieve it earlier, so much the better. Surely the Government would be unwise not to do so and we have decided that we shall do so. If however we find that it could not be done, the public or Government should intervene. Then surely everybody will understand why public sector becomes more and more important. We want to encourage both. It all depends upon the results that we are able to achieve. There is abundant river wealth in this country, and we should exploit it as far as possible.

If you want to make progress in the right direction and you expect any assistance from Government, you will find that you get it in larger measure than you expect it.

(*Being the speech delivered by the Minister for Irrigation and Power, Government of India, at the General Meeting of the Federation of Electricity undertakings in India on Dec.* 12, 1957.)

Continued from page 6

Krishna Barrage Project

Up-to-date, half the number of shutters were manufactured and a further supply of 500 tons of steel is awaited to complete the balance of shutters, which are proposed to be erected before next June.

The work was estimated to cost Rs. 2.84 crores and up-to-date expenditure is Rs. 2.30 crores. The work is being completed with a savings of about Rs. 15 lakhs. The original estimate of Rs. 2.84 crores for the structure was priced at the schedule of rates of 1953. There is an increase in cost of materials since then, especially very high increase in cost of cement and steel. In spite of it, the work could be completed with savings over the old estimate on account of efficient management of work by the Departmental officers and contractors, good co-operation from the labour, and the missionary zeal with which the staff connected with the work worked day and night round the clock, some of them attending more than one shift. The establishment charges on the project therefore worked out to only 2½ per cent of the cost of the estimate. The Krishna Barrage Project was also completed 6 months ahead of the schedule.

A Statement showing details of barrages constructed in India is appended. It discloses that the Krishna Barrage has been executed very economically and expeditiously when compared with other barrages in India. Barrages involving less quantities of masonry and concrete in the structure costed more; Barrages which discharge less flood than the Krishna costed more; Barrages on smaller rivers costed more. A quotation from the speech delivered in the Parliament on 1-8-'57 by Sri S. K. Patil, Union Minister for Irrigation & Power, is given below:—

"I am not an engineer myself, but I have got a robust commonsense to understand one thing from the other. Krishna Barrage has been constructed at the cheapest and most economically possible basis. When it is completed you will find that it will give us more per rupee than any other dam that will come up in the country."

Continued from page 12

Thermal Power Stations

In the drive for economy in the cost of power stations, an outdoor design has been evolved. This was first developed in U. S. A. and now it is finding increasing acceptance elsewhere. The outdoor boiler is firmly established, but it is still doubtful if outdoor turbines save anything. The greatest saving in building cost is obtained where the fuel is oil or gas and most outdoor plants use these fuels. The outdoor plant has its place particularly where the climate is not extreme. Much difference of opinion still exists regarding the relative advantages and disadvantages of indoor and outdoor plant. Semi-outdoor station is more popular than the fully outdoor one.

A semi-outdoor station at Ince in U. K. has been in operation for sometime and in view of satisfactory results another semi-outdoor station, Willingdon 'B', is being designed.

Trombay thermal station in India is a semi-outdoor one. At this station the boilers are fully outdoor and the turbo-alternators are weather proofed by low brickwalls and removable hatches in the roof. A 50-ton gentry crane serves the full length of the turbine floor deck.

DVC's Durgapur thermal station is also being designed as semioutdoor.

It is difficult to assess the saving in the cost of outdoor stations. As the superstructure of the conventional power station is primarily designed for supporting the generating plant, crane and auxiliaries, the weather proofing is only a subsidiary function of the same. As such, the cost of weather proofing does not form a very large proportion of the overall cost of the building and, therefore, there is no spectacular saving in the outdoor design of a station. In U. S. A. the saving is considered to be about $5 per kW. and in U. K. about £1 per kW. of installed capacity.

An outdoor station will fit in better in a large interconnected system than as an isolated unit, as possible delay in completion of scheduled or emergency maintenance in a bad weather will not jeopardise the supply so much in a large system as it would do in an isolated station.

In most of the potential sites of thermal power stations in India, the problem is rainfall and excessive heat in the summer, but not the freezing temperature. The outdoor design, therefore, holds better prospects future in this country.

[*Based on the lectures delivered in Bombay under the auspices of the Institute of Engineers (India) Bombay Centre.*]

To be continued

Calculation with the Energy-Head

By Dr.-Ing. P. G. FRANKE

The advantage in calculating with the total head and especially with relative numbers will be explained in this article. A short expose of the matter is given in the beginning. Three illustrations are attached. All the relations are explained for rectangular cross section. The methods are applicable to any other cross section also.

1. The basic equations

The head of energy above the channel floor is expressed as

$$H = y + \alpha k = y + \alpha \frac{v^2}{2g} \qquad (1)$$

and the discharge per meter largness of a rectangular channel is

$$q = \frac{Q}{b} = y.v \qquad (2)$$

in which the terms are as under

y = depth of water
v = mean velocity in the cross section area F
k = mean velocity head
α = correcting factor of the mean velocity head
Q = discharge in unit of time
b = width of the flume

Equation (2) can also be used for any other very large channel ($b >> y$). Then the value of y is to be taken as mean value of depth.

For the average velocity in the concerned cross section the equation

$$v = \sqrt{\frac{2g}{\alpha}} \sqrt{H-y} \qquad (3)$$

is obtained. Hence follows for the discharge per largness-meter

$$q = y\sqrt{\frac{2g}{\alpha}} \sqrt{H-y} \qquad (4)$$

In two particular cases when y=0 and y=H will be q=o. Between these an extreme value lies, which is a maximum. Critical depth y_c and critical velocity v_c are the corresponding values of q_{max}. Over this stage, in the subcritical region, the flow forms are calm, streaming or tranquil and below them, in the supercritical region, they are tear, gushing or shooting.

Criterion :

Condition	*Depth*	*Velocity*	*Discharge*
Subcritical flow	$y > y_c$	$v < v_c$	$q < q_{max}$
Critical stage	$y = y_c$	$v = v_c$	$q = q_{max}$
Supercritical flow	$y < y_c$	$v > v_c$	$q < q_{max}$

Any discharge $q < q_{max}$ occurs twice. For these corresponding values under one head of energy the symbols are used as : In the subcritical region y′ and v′ and in the supercritical region y″ and v″.

In correct form also must be written for the correcting factor of the mean velocity-head α' and α''. However, with regard to the difficulties of the precise seizing in practice an average value $\alpha' = \alpha'' = \alpha$ is normally used. As a guiding rule may be employed :

Subcritical flow	$1.05 < \alpha < 1.15$
Supercritical flow	$1.00 < \alpha < 1.05$

In the subcritical region the value $\alpha = 1.09$ is frequently applied with which results $\frac{2g}{\alpha} = 18$ [m/sec²].

2. The critical depth y_c for H=const.

If the first derivative of equation (4) is equated to zero

$$\frac{dq}{dy} = \sqrt{\frac{2g}{\alpha}} \left[(H-y)^{1/2} - \frac{y}{2}(H-y)^{-1/2} \right] = 0$$

then is obtained

$$y = \tfrac{2}{3}H = y_c \qquad (5)$$

The critical depth y_c is that specific depth of water with which the maximum discharge under the existing head of energy is possible.

3. The maximum discharge q_{max} for H-const.

Proceeding from equation (4) for this particular case is

$$q_{max}=y_c\sqrt{\frac{2g}{\alpha}}\sqrt{H-y_c} \qquad (6)$$

Two possibilities can be arrived at the further considerations

Substituting $y_c=\frac{2}{3}H$ into the above formula follows the expression

$$q_{max}=\frac{2}{3}H\sqrt{\frac{2g}{\alpha}\frac{H}{3}}$$

or

$$q_{max}=\frac{1.705}{\sqrt{\alpha}}H\sqrt{H} \qquad (7)$$

Substituting $H=\frac{3}{2}y_c$ equation (6) is converted into

$$q_{max}=y_c\sqrt{\frac{g}{\alpha}}y_c$$

or

$$q_{max}=\frac{3.132}{\sqrt{\alpha}}y_c\sqrt{y_c} \qquad (8)$$

4. The critical velocity v_c

From equation (8) it is following for $q_{max}=y_c\,v_c$ the expression for the critical velocity

$$v_c=\sqrt{\frac{g}{\alpha}y_c}=\frac{3.132}{\sqrt{\alpha}}\sqrt{y_c} \qquad (9)$$

In the case of $\alpha=1$ the well-known formula

$$v_c=\sqrt{gy_c}=3.133\sqrt{y_c}$$

is arrived at.

The critical velocity is also the velocity of surges and the velocity of waves in shallow water.

5. The minimum energy head H_{min} for q=const.

The concerned rate of flow may even be discharged under the energy head H_{min}. This condition is only accomplished if $q=q_{max}$ and $y=y_c$.

From equation (8) it is obtained

$$q^2_{max}=\frac{g}{\alpha}y_c^3=q^2$$

therefore

$$y_c=\sqrt[3]{\alpha\frac{q^2}{g}}=0.467\sqrt[3]{\alpha}\sqrt[3]{q^2}=\frac{2}{3}H_{min} \qquad (10)$$

and

$$H_{min}=\frac{3}{2}y_c=\frac{3}{2}\sqrt[3]{\alpha\frac{q^2}{g}}=0.701\sqrt[3]{\alpha}\sqrt[3]{q^2} \qquad (11)$$

These formulae are frequently applied as the discharge is often given and the unknown minimum head of energy, which is able to transmit the concerned water amount through the cross section, is to be found out.

6. The H-line

It is supposed that the discharge is constant and the energy head will vary with the depths of water. If these values of H are drawn in a graph the H-line for $H=H(y)$ and $q=$const is obtained.

In the particular case of a dimensionless form there are some simplifications possible. If each term of the equation

$$H=y+\frac{\alpha}{2g}v^2=y+\frac{\alpha}{2g}\frac{q^2}{y^2} \qquad (12)$$

is divided by the critical depth y_c and substituted

$$\frac{q}{\alpha}y_c^3=q^2$$

which is derivated for equation (10), where $q=$ const. it will follow that

$$\frac{H}{y_c}=\frac{y}{y_c}+\frac{1}{2}\frac{y_c^3}{y^2} \qquad (13)$$

Some relative numbers are contained in table 1 and the diagram is shown in figure 1.

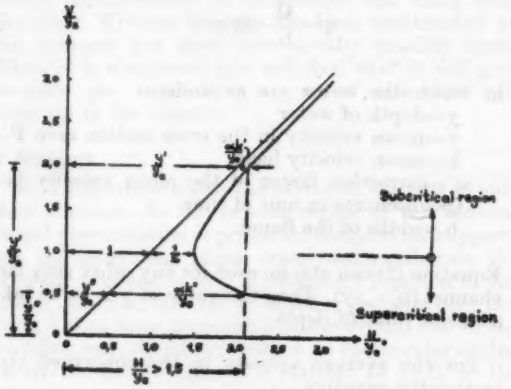


Fig. 1: The specific-head diagram.

The value of H below which the concerned flow rate may be discharged only once is H_{min}. To this are corresponding the so-called values of limit or critical values y_c and v_c or k_c respectively. In the case of $H>H_{min}$ two alternate depths for any given rate of flow will exist, one higher than the critical and the other lower than the critical.

For each discharge q the critical depth y_c can be calculated with equation (10). Then equation (13) is to be used in finding out the respective head of energy for any desired water-depth or for any energy-head the corresponding water-depths can be obtained.

7. The q-line

If the values of q for H=const are drawn in relation to the water depth y the diagram of the discharge-line is obtained (figure 2).

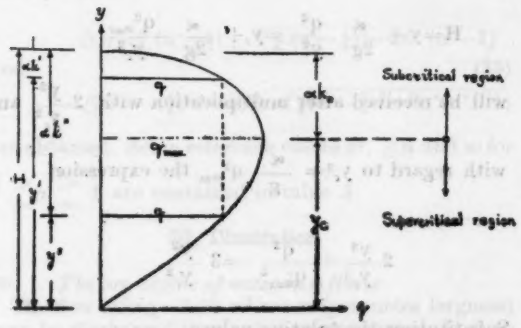


Fig. 2: The q-line for q=q (y) and H=const.

It is evident that for any particular energy head, when $q<q_{max}$ two alternative depths are corresponding, one in the subcritical reach with $y'>y_c$ and one in the supercritical reach with $y''<y_c$. Subsequently follows with the simplification $\alpha=1$

$$H=y'+k'=y''+k''$$

and with the equation of continuity

$$q=y'v'=y''v''$$

the corresponding water depth can be expressed as under

$$y'=\frac{k''}{2}+(-)\sqrt{\frac{k''^2}{4}+k''y''} \qquad (14)$$

$$y''=\frac{k'}{2}+(-)\sqrt{\frac{k'^2}{4}+k'y'}$$

Between the two possibilities of a discharge for $q<q_{max}$ the difference of water depths will be

$$\Delta y=y'-y'' \qquad (15)$$

or

$$\Delta y=y'-\tfrac{1}{2}\left(k'+(-)\sqrt{k'^2+4k'y'}\right)$$

$$\Delta y=\tfrac{1}{2}\left(k''+(-)\sqrt{k''^2+4k''y''}\right)-y''. \qquad (16)$$

From the above the equations of the relative values which are sometimes used

$$\frac{y'}{y''} \text{ or } \frac{y''}{y'}$$

and

$$\frac{\Delta y}{y'}=1-\frac{y''}{y'} \text{ or } \frac{\Delta y}{y''}=\frac{y'}{y''}-1$$

can be derived.

8. The proportional factors ρ and σ by K. Flierl

Re-writing equation (4) into the following form

$$q=y\frac{H}{H}\sqrt{\frac{2g}{\alpha}}\sqrt{H\left(1-\frac{y}{H}\right)}$$

and substituting

$$\frac{y}{H}=\rho \qquad (17)$$

the dimensionless form

$$\frac{q}{\sqrt{\frac{2g}{\alpha}}H\sqrt{H}}=\rho\sqrt{1-\rho}=\sigma \qquad (18)$$

will be obtained, in which the limits are

$$0\leqq\rho\leqq 1 \text{ and } 0\leqq\sigma\leqq 0.384900.$$

Therefore for the number of ρ the corresponding value of σ can be calculated once and for all (table 2)*. Instead of each q-line, related to every value of H, only a single unit-q-line is obtained which is the so-called σ-line (figure 3).

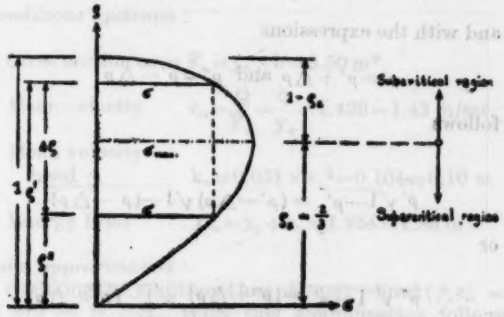


Fig. 3: The σ-line.
$y'=\rho' H;\ y_c=\rho_c H=\frac{2}{3}H;\ y''=\rho'' H.$

If q and H are given, the number σ can be worked out from the equation (18) and from a schedule or a diagram the concerned number ρ will be found out. The expected depth of water follows as

$$y=\rho H.$$

The critical value between subcritical and supercritical flow is $\rho_c=\frac{2}{3}$.

Referring equation (18), the discharge is given in the following expression

$$q=\sigma\sqrt{\frac{2g}{\alpha}}H\sqrt{H} \qquad (19)$$

---

* More complete tables are contained in
Franke, P.: Berechnung der Wasserspiegellage für die stationär ungleichförmige Strömung in offenen Gerinnen. Franckh, Stuttgart 1950.
With intervals 0.001 in ρ from 1.000 to 0.900 and 4 decimals in σ
" " 0.005 " " " 0.900 to 0.700 " 4 " " " "
" " 0.001 " " " 0.700 to 0.600 " 6 " " "
" " 0.005 " " " 0.600 to 0.500 " 4 " " "
" " 0.010 " " " 0.500 to 0 " 4 " " "

Flierl, K.: Zahlentafeln und Kurven zum Rechnen mit der Energielinie fur Rechteck—und Trapezgerinne. Mitteilungen der Versuchsanstalt für Wasserbau der Technischen Hochschule München. Oldenbourg, München 1953, No 1, pp. 1-41.
With the same intervals in ρ as above and throughout 6 decimals in σ.

With $\sigma_{max}\sqrt{2g} = 0.38494.429 = 1.705$ for the maximum discharge

$$q_{max} = \frac{1{,}705}{\sqrt{\alpha}} H^{3/2} \tag{7}$$

is obtained again.

The difference of water depth between the two possibilities of discharge for any $q < q_{max}$ is expressed as

$$\Delta y = (\rho' - \rho'')\ H = \Delta\rho\ H$$

The calculation of this head is for example necessary for the hydraulic jump, as it is the real head of the lift which occurs on the end of the retardation zone.

For each value $\sigma < \sigma_{max}$ can also be weitten

$$\sigma = \rho'\sqrt{1-\rho'} = \rho''\sqrt{1-\rho''}$$

and with the expressions

$$\rho' = \rho'' + \Delta\rho \quad \text{and} \quad \rho'' = \rho' - \Delta\rho$$

follows

$$\rho'\sqrt{1-\rho'} = (\rho' - \Delta\rho)\sqrt{1-(\rho'-\Delta\rho)}$$

or

$$\rho''\sqrt{1-\rho''} = (\rho'' + \Delta\rho)\sqrt{1-(\rho''+\Delta\rho)}$$

and finally for $\Delta\rho$ is obtained

$$\Delta\rho = \frac{3\rho'-1}{2} \underset{(-)}{+} \sqrt{\left(\frac{3\rho'-1}{2}\right)^2 - \rho'(3\rho'-2)}$$

or (12)

$$\Delta\rho = -\frac{3\rho''-1}{2} \underset{(-)}{+} \sqrt{\left(\frac{3\rho''-1}{2}\right)^2 - \rho''(3\rho''-2)}$$

To each relative numbers ρ corresponds a value $\Delta\rho$. It is

$$1 \geqq \Delta\rho \geqq 0 \qquad \text{for} \qquad 1 \geqq \rho \geqq \tfrac{2}{3}$$

and

$$0 \leqq \Delta\rho \leqq 1 \qquad \text{for} \qquad \tfrac{2}{3} \geqq \rho \geqq 0.$$

The value $\Delta\rho$ can be found out from the reference table 2 for $\sigma = \sigma(\rho)$ as it is the difference bewteen the two corresponding values ρ' and ρ''. It is also possible to use a schedule which contains for the values ρ'' the corresponding values ρ', $\Delta\rho$ and σ (table 3).**

(**) A complete table with intervals of 0.001 for ρ' and six decimals for ρ'', $\Delta\rho$ and σ is contained in
Franke, P.: Der Wechselsprung mit freier Deckwalze. Mitteilungen aus dem Gebiete des Wasserbaues und der Baugrundforschung, Heft 17. Ernst & Sohn, Berlin 1955.

9. The proportional factors m and n

From the general equation

$$H = y + \alpha k = y_c + \alpha k_c$$

or

$$H = y + \frac{\alpha}{2g}\frac{q^2}{y^2} = y_c + \frac{\alpha}{2g}\frac{q^2_{max}}{y_c^2}$$

will be received after multiplication with $2\frac{y^2}{y_c^2}$ and with regard to $y_c^3 = \frac{\alpha}{g} q^2_{max}$ the expression

$$2\frac{y^3}{y_c^3} + \frac{q^2}{q_{max}^2} = 3\frac{y^2}{y_c^2}$$

Substituting the relative values

$$m = \frac{q}{q_{max}} \quad \text{and} \quad n = \frac{y}{y_c} \tag{22}$$

from the above is obtained

$$m = n\sqrt{3-2n} \tag{23}$$

It is possible to calculate for each value $0 \leqq n \leqq \frac{3}{2}$ the corresponding number $0 \leqq m \leqq 1$ (table 4). The diagram of the values $m = m(n)$ is prepared in figure 4, it is similar to the σ-line.

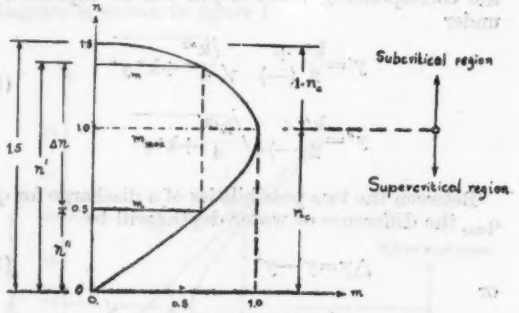


Fig. 4: The m-line.

If q and q_{max} are given, the relative number m is also known (equ. 22) the corresponding numbers $1 < n' < \frac{3}{2}$ (subcritical flow) or $0 < n'' < 1$ (supercritical flow) can be found out and further the depth of water from the equation

$$y' = n' y_c \quad \text{or} \quad y'' = n'' y_c$$

will be worked out. On the other hand for a known n-value the number m and the discharge

$$q = m\ q_{max} \tag{24}$$

can be calculated.

Further, to each relative number, except $n = 1$, pertains a value

$$\Delta n = n' - n''$$

From the expression

$$m^2=3n'^2-2n'^3=3n''^2-2n''^3$$

the equations

$$\triangle n=\tfrac{3}{2}(n'-\tfrac{1}{2})\pm\sqrt{\tfrac{9}{4}(n'-\tfrac{1}{2})^2-3n'(n'-1)} \quad (25)$$

and

$$\triangle n=-\tfrac{3}{2}(n''-\tfrac{1}{2})\pm\sqrt{\tfrac{9}{4}(n''-\tfrac{1}{2})^2-3n''(n''-1)}$$

are obtained. Some reference values n'', $\triangle n$ and m for $\frac{3}{2}\geqq n'\geqq 1$ are contained in table 5.

10. Illustration

10. 1. *The two depths of water in a flume*

The flow rate $q=3{,}00\ m^3/sec\ m$ (per meter largness) may be discharged in a rectangular channel. It is to work out with what depths of water it can occur when the head of energy is $H=2.25m$ (figure 5). To simplify the calculations, $\alpha=1$ can be used.

Fig. 5: The two water depth for H=const.

For the relative number σ is obtained (equation 18)

$$\sigma=\frac{q}{\sqrt{2g}\,H\,\sqrt{H}}=\frac{3.00}{4.429\times2.25\times1.50}=0.2007$$

The corresponding values of ρ can be found out from the table 2 or 3 and the unknown depths of water will be thus calculated.

Subcritical flow: $\rho>\frac{2}{3}$

Relative number	$\rho'=0.9559$
Water depth	$y'=\rho' H=2.151=2.15$ m
Mean velocity	$v'=q/y'=1.395=1.39$ m/sec
Mean velocity-head	$k'=0.051\ v'^2=0.099=0.10$ m
Energy-head (control)	$H=y'+k'=2.25$ m

Supercritical: $\rho<\frac{2}{3}$

Relative number	$\rho''=0.2285$
Water depth	$y''=\rho''H=0.515=0.52$ m
Mean velocity	$v''=q/y''=5.824=5.82$ m/sec
Mean velocity-head	$k''=0.051.\ v''^2=1.735=1.73$ m
Energy-head (control)	$H=y''+k''=2.25$m

In each case of discharge naturally the slope of the channel must be so arranged that the head of energy along the same is constant.

10.2. *The discharge below a sharp-edged gate*

Directly upstream of a gate in a flume of the width $b=2.00m$ must be a constant water level with the depth of $y_o=1.75m$. The necessary stroke of the gate under a discharge $Q=5.00m^3/sec$ is to be calculated. It can be assumed $\alpha=1$.

The section upstream is signified with (O) and this in the low with (1). The number Ψ is called coefficient of contraction. It is a function of the relative number $n=\frac{y_o}{a}$ (figure 6).

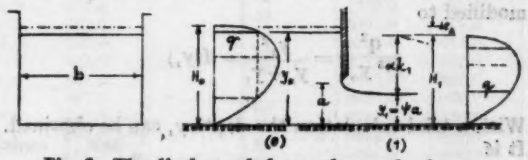


Fig. 6: The discharge below a sharp-edged gate.

Flow rate: $q=\frac{Q}{b}=2.50\ m^3/sec.\ m$

Conditions upstream:

Cross section area	$F_o=y_o\times b=3.50\ m^2$
Mean velocity	$v_o=\frac{Q}{F_o}=\frac{q}{y_o}=1.429=1.43$ m/sec
Mean velocity head	$k_o=0.051\times v_o^2=0.104=0.10$ m
Energy head	$H_o=y_o+k_o=1.854=1.85$ m

First approximation:

Omitting the additional loss of energy-head ($\triangle e_A=0$) will be $H_1=H_o$. With this simplification follows the depth $y_1=\bar{y}_1$ as the corresponding value to y_o.

Relative numbers: $\rho'_o=\frac{y_o}{H_o}=0.9439$

$\sigma_o=0.2236$ and $\rho''_o=0.2627$

Depth of water: $\bar{y}_1=y_o''=\rho''_o H_o=0.487=0.49$ m

Gate stroke: With an assumed value $\Psi=0.62$ follows

$$a=\frac{\bar{y}_1}{\Psi}=0.79\ m$$

Ratio of opening: $n=\frac{y_o}{a}=\Psi\frac{y_o}{y_1}=2.23.$

It must be notified that with $\Delta e_A=0$ the value $\bar{y}_1=y_o''$ is less than the real depth y_1 in the low section. Considering this, however, it is possible to proceed further.

Second calculation

For the discharge below a sharp-edged gate the formula***

$$q=\Phi^*\sqrt{2g}\,\frac{y_o y_1}{\sqrt{y_o+y_1}}=C\,\frac{y_o y_1}{\sqrt{y_o+y_1}}$$

*** Franke, P.: Der Abfluss unter einer scharfkantigen Planschütze Diss. Technische Hochschule München 1952/53.

Dto. Contributo all a valutazione delle piccole portate nei canali aperti. Ingegneri—Architetti—Costruttori 11, Bologna 1956, No, 12, pp. 323—325.

exists, where Φ^* is the coefficient of velocity which regards the additional losses. This coefficient is independent of the correcting factor α.

For an assumed ratio of opening n=2.15 the empiric values are

$$\Phi^*=0.95 \quad \text{and} \quad \Psi=0.63$$

The above mentioned equation of discharge can be modified to

$$\frac{q^2}{C^2 y_o^2}=\frac{y_1^2}{y_o+y_1}=f(y_1)$$

With a trial calculation the depth y_1 can be obtained. It is

$$f(y_1)=\frac{q^2}{C^2 y_o^2}=\frac{6.25}{54.057}=0.1156$$

and

y_1	0.50	0.52
y_1^2	0.2500	0.2704
y_o+y_1	2.25	2.27
$f(y_1)$	0.1111	0.1191
Diff. :	+0.0045	−0.0035

Therefore follows :

Water depth $y_1=0.500+0.0045 \quad \frac{0.02}{0.0080}=0.511$

$=0.51$ m

Gate stroke $\quad a=\frac{y_1}{\Psi}=0.81$ m

Relative number $n=\frac{y_o}{a}=2.15$.

The applied assumption is correct. Otherwise a new step of calculation with corrected values would be necessary.

The solution may also be possible by the $\rho-\sigma$ - method. For the discharge exists just so the equation

$$q=y_1 \Phi^* \sqrt{2g} \sqrt{y_o+\frac{1}{\Phi^{*2}}k_o-y_1}=y_1 C \sqrt{A-y_1}$$

which is identical with the above mentioned formula. From the modification

$$q=y_1\frac{A}{A} C \sqrt{A\left(1-\frac{y_1}{A}\right)}$$

follows with

$$\rho_1=\frac{y_1}{A}$$

the dimensionless form

$$\frac{q}{CA\sqrt{A}}=\rho_1\sqrt{1-\rho_1}=\sigma.$$

In this case is :

$$A=y_o+\frac{1}{\Phi^{*2}}k_o=1.865 \text{ and } \sqrt{A}=1.366.$$

$$\sigma=\frac{q}{CA\sqrt{A}}=0.2335 \text{ and } \rho_1=0.2741.$$

$$y_1=\rho_1 \cdot A=0.511=0.51 \text{ m}$$

$$a=\frac{y_1}{\Psi}=0.81 \text{ m and } n=\frac{y_o}{a}=2.15.$$

The advantage of using the $\rho-\sigma$—method for this calculation is self-explanatory.

10.3. *The flow conditions over a bund*

The steady uniform flow exists in a flume. It is to exhibit what kind of flow conditions may be possible on account of a hump and those in the cases of (fig. 7):

(*a*) Mild basic flow (subcritical region)
(*b*) Steep basic flow (supercritical region)

The heads in the undisturbed conditions have the index (u) and those over the bund (similar to a broad-crested weir) have the index (w). In these considerations the loss of head in the zone of the hump may be neglected.

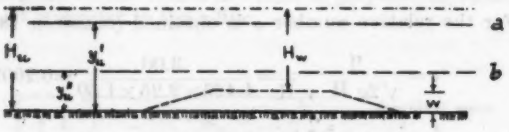


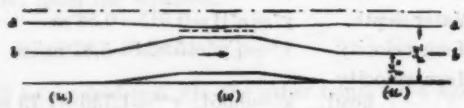
Fig. 7: Steady uniform flow in a flume.
(a) Mild basic flow.
(b) Steep basic flow.

In the stage where the original energy level with head H_u over the base will even be sufficient to discharge the given flowrate over the bund, the concerned head of the bund will be indicated in term of w_c. Further three general cases are to be distinguished.

1*st case* : $\quad w<w_c \quad$ or $\quad H_{min}+w<H_u$

Therefore follows (fig. 8) $H_u - w=H_w > H_{min}$ and

$y_w \lessgtr y_c$.



$$y_u' > y_w' > y_c$$
$$y_u'' < y_w'' < y_c$$

Fig. 8: Flow over a bund: $w < w_c$

The discharge is possible under the existing energy level.

2*nd case* : $\quad w=w_c \quad$ or $\quad H_{min}+w=H_u$

[*Continued on page 26*]

Table 1: Values $\frac{y}{y_c}$ and $\frac{H}{y_c}$

$\frac{y}{y_c}$	$\frac{H}{y_c}$
5.00	5.0200
4.90	3.0065
2.90	2.9898
2.80	2.8888
2.70	2.7886
2.60	2.6890
2.50	2.5900
2.40	2.4918
2.30	2.3945
2.20	2.3083
2.10	2.2134
2.00	2.1250
1.90	2.0385
1.80	1.9543
1.70	1.8730
1.60	1.7953
1.50	1.7222
1.40	1.6551
1.30	1.5956
1.20	1.5472
1.10	1.5132
1.00	1.5000
0.90	1.5173
0.80	1.5812
0.70	1.7204
0.60	1.9830
0.50	2.5098
0.40	3.5258
0.30	5.8555
0.20	12.7000
0.10	50.1000
0	∞

Table 2: Values ρ and σ

Δρ	ρ	σ	Δσ	Δρ	ρ	σ	Δσ	Δρ	ρ	σ	Δσ
	1.000	0.0000	0.0446		0.840	0.3360	32		0.636	0.383714	157
0.002	0.998	0.0446	184	0.005	0.835	0.3392	30	0.002	0.634	557	167
	0.996	0.0630	140		0.830	0.3422	29		0.632	390	176
	0.994	0.0770	117		0.825	0.3451	28		0.630	214	185
	0.992	0.0887	103		0.820	0.3479	26		0.628	0.383029	195
	0.990	0.0990	92		0.815	0.3505	26		0.626	0.382834	204
	0.988	0.1082	85		0.810	0.3531	24		0.624	630	214
	0.986	0.1167	78		0.805	0.3555	23		0.622	416	222
	0.984	0.1245	72		0.800	0.3578	22		0.620	194	232
	0.982	0.1317	69		0.795	0.3600	20		0.618	0.381962	241
	0.980	0.1386	65		0.790	0.3620	20		0.616	721	249
	0.978	0.1451	61		0.785	0.3640	19		0.614	472	259
	0.976	0.1512	59		0.780	0.3659	17		0.612	213	268
	0.974	0.1571	55		0.775	0.3676	17		0.610	0.380945	276
	0.972	0.1626	54		0.770	0.3693	15		0.608	669	286
	0.970	0.1680	52		0.765	0.3708	15		0.606	383	295
	0.968	0.1732	49		0.760	0.3723	14		0.604	0.380088	303
	0.966	0.1781	48		0.755	0.3737	13	0.002	0.602	0.379785	312
	0.964	0.1829	46		0.750	0.3750	12	0.005	0.600	0.379473	713
	0.962	0.1875	45		0.745	0.3762	11		0.595	0.3787	9
	0.960	0.1920	43		0.740	0.3773	11		0.590	0.3778	9
	0.958	0.1963	42		0.735	0.3784	9		0.585	0.3769	10
	0.956	0.2005	41		0.730	0.3793	9		0.580	0.3759	10
	0.954	0.2046	40		0.725	0.3802	8		0.575	0.3749	11
	0.952	0.2086	38		0.720	0.3810	7		0.570	0.3738	12
	0.950	0.2124	38		0.715	0.3817	6	0.005	0.565	0.3726	11
	0.948	0.2162	36		0.710	0.3823	6		0.560	0.3715	13
	0.946	0.2198	36		0.705	0.3829	0.000506		0.555	0.3702	12
	0.944	0.2234	35	0.005	0.700	0.383406	0.000177		0.550	0.6690	14
	0.942	0.2269	34	0.002	0.698	0.383583	165		0.545	0.3676	14
	0.940	0.2303	33		0.696	0.383748	154		0.540	0.3662	14
	0.938	0.2336	32		0.694	0.383902	142		0.535	0.3648	15
	0.936	0.2368	31		0.692	0.384044	132		0.530	0.3633	15
	0.934	0.2399	31		0.690	176	120		0.525	0.3618	15
	0.932	0.2430	31		0.688	296	109		0.520	0.3603	16
	0.930	0.2461	29		0.686	405	98		0.515	0.3587	17
	0.928	0.2490	29		0.684	503	87		0.510	0.3570	17
	0.926	0.2519	28		0.682	590	76	0.005	0.505	0.3553	17
	0.924	0.2547	28		0.680	666	65	0.010	0.500	0.3536	37
	0.922	0.2575	27		0.678	731	55		0.490	0.3499	38
	0.920	0.2602	27		0.676	786	44		0.480	0.3461	39
	0.918	0.2629	26		0.674	830	33		0.470	0.3422	42
	0.916	0.2655	25		0.672	863	23		0.460	0.3380	43
	0.914	0.2680	25	0.002	0.670	886	12		0.450	0.3337	44
	0.912	0.2705	25	0.001	0.668	898	2		0.440	0.3293	47
	0.910	0.2730	24		0.667	9.000	01		0.430	0.3246	47
	0.908	0.2745	24	0.001			05		0.420	0.3199	50
	0.906	0.2778	23	0.002	2/3	0.384900	8		0.410	0.3149	51
	0.904	0.2801	23		0.666	899	19		0.400	0.3098	52
0.002	0.902	0.2824	22		0.664	891	29		0.390	0.3046	54
0.005	0.900	0.2846	54		0.662	872	39		0.380	0.2992	55
	0.895	0.2900	52		0.660	843	50		0.370	0.2937	57
	0.890	0.2952	49		0.658	804	60		0.360	0.2880	58
	0.885	0.3001	47		0.656	754	69		0.350	0.2822	60
	0.880	0.3048	46		0.654	694	80		0.340	0.2762	61
	0.875	0.3094	43		0.652	625	89		0.330	0.2701	62
	0.870	0.3137	41		0.650	545	100		0.320	0.2639	64
	0.865	0.3178	40		0.648	456	110		0.310	0.2575	65
	0.860	0.3218	38		0.646	356	119		0.300	0.2510	66
	0.855	0.3256	36		0.644	247	128		0.290	0.2444	68
	0.850	0.3292	35		0.642	128	138		0.280	0.2376	69
	0.845	0.3327	33		0.640	0.384000	148		0.270	0.2307	70
	0.840	0.3360			0.638	0.383862			0.260	0.2237	72
					0.636	714			0.250	0.2165	73
									0.240	0.2092	74
									0.230	0.2018	75
									0.220	0.1943	76
									0.210	0.1867	78
									0.200	0.1789	79
									0.190	0.1710	80
									0.180	0.1630	81
									0.170	0.1549	83
									0.160	0.1466	83
									0.150	0.1383	85
									0.140	0.1298	85
									0.130	0.1213	87
									0.120	0.1126	88
									0.110	0.1038	89
									0.100	0.0949	90
									0.090	0.0859	92
									0.080	0.0767	92
									0.070	0.0676	93
									0.060	0.0582	95
									0.050	0.0487	95
									0.040	0.0392	96
									0.030	0.0296	96
									0.020	0.0198	98
									0.010	0.0100	98
									0.000	0.0000	100

Table 3. Values ρ', $\Delta\rho$ and σ for $1 \geqq \rho' \geqq \frac{3}{4}$.

ρ	ρ'	$\Delta\rho$	σ
1.000	0.0000	1.0000	0.0000
0.990	0.1046	0.8854	0.0980
0.980	0.1504	0.8296	0.1386
0.970	0.1862	0.7838	0.1680
0.960	0.2170	0.7430	0.1920
0.950	0.2444	0.7056	0.2124
0.940	0.2694	0.6706	0.2303
0.930	0.2925	0.6375	0.2461
0.920	0.3142	0.6058	0.2602
0.910	0.3347	0.5755	0.2730
0.900	0.3541	0.5459	0.2846
0.890	0.3727	0.5173	0.2925
0.880	0.3905	0.4895	0.3043
0.870	0.4075	0.4623	0.3137
0.860	0.4240	0.4360	0.3218
0.850	0.4399	0.4101	0.3282
0.840	0.4552	0.3848	0.3360
0.830	0.4701	0.3599	0.3429
0.820	0.4846	0.3354	0.3479
0.810	0.4986	0.3113	0.3531
0.800	0.5123	0.2877	0.3579
0.790	0.5256	0.2644	0.3620
0.780	0.5386	0.2414	0.3659
0.770	0.5513	0.2187	0.3693
0.760	0.5636	0.1964	0.3723
0.750	0.5757	0.1743	0.3750
0.740	0.5875	0.1525	0.3773
0.730	0.5990	0.1310	0.3793
0.720	0.6103	0.1097	0.3810
0.710	0.6214	0.0886	0.3823
0.706	0.6322	0.0678	0.3834
0.690	0.6428	0.0473	0.3842
0.680	0.6533	0.0268	0.3847
0.670	0.6633	0.0067	0.3849
$\frac{3}{4}$	1	0.0000	0.3849

Table 5 : Values n', Δn and m for $\frac{3}{4} \geqq n' \geqq 1$.

n	n'	Δn	m
1.50	0.0000	1.5000	0,0000
1.48	0.1824	1.2976	0.2960
1.46	0.2498	1.2102	0.4129
1.44	0.3254	1.1140	0.4988
1.42	0.3794	1.0406	0.5680
1.40	0.4275	0.9725	0.6261
1.38	0.4713	0.9087	0.6761
1.36	0.5119	0.8481	0.7197
1.34	0.5498	0.7902	0.7580
1.32	0.5863	0.7337	0.7920
1.30	0.6196	0.6804	0.8222
1.28	0.6519	0.6281	0.8490
1.26	0.6828	0.5772	0.8729
1.24	0.7125	0.5275	0.8942
1.22	0.7409	0.4791	0.9129
1.20	0.7684	0.4316	0.9295
1.18	0.7949	0.3851	0.9440
1.16	0.8206	0.3394	0.9565
1.14	0.8455	0.2945	0.9673
1.12	0.8695	0.2505	0.9764
1.10	0.8928	0.2072	0.9839
1.08	0.9155	0.1645	0.9898
1.06	0.9374	0.1226	0.9944
1.04	0.9588	0.0812	0.9976
1.02	0.9798	0.0402	0.9994
1.00	1.0000	0.0000	1.0000

exists, where Φ^* is the coefficient of velocity which regards the additional losses. This coefficient is independent of the correcting factor α.

For an assumed ratio of opening n=2.15 the empiric values are

$$\Phi^*=0.95 \quad \text{and} \quad \Psi=0.63$$

The above mentioned equation of discharge can be modified to

$$\frac{q^2}{C^2 y_o^2}=\frac{y_1^2}{y_o+y_1}=f(y_1)$$

With a trial calculation the depth y_1 can be obtained. It is

$$f(y_1)=\frac{q^2}{C^2 y_o^2}=\frac{6.25}{54.057}=0.1156$$

and

y_1	0.50	0.52
y_1^2	0.2500	0.2704
y_o+y_1	2.25	2.27
$f(y_1)$	0.1111	0.1191
Diff. :	+0.0045	−0.0035

Therefore follows :

Water depth $y_1=0.500+0.0045\ \frac{0.02}{0.0080}=0.511$

$=0.51$ m

Gate stroke $a=\frac{y_1}{\Psi}=0.81$ m

Relative number $n=\frac{y_o}{a}=2.15$.

The applied assumption is correct. Otherwise a new step of calculation with corrected values would be necessary.

The solution may also be possible by the $\rho-\sigma$ - method. For the discharge exists just so the equation

$$q=y_1 \Phi^* \sqrt{2g}\sqrt{y_o+\frac{1}{\Phi^{*2}}k_o-y_1}=y_1\ C\sqrt{A-y_1}$$

which is identical with the above mentioned formula. From the modification

$$q=y_1\frac{A}{A}\ C\sqrt{A\left(1-\frac{y_1}{A}\right)}$$

follows with

$$\rho_1=\frac{y_1}{A}$$

the dimensionless form

$$\frac{q}{CA\sqrt{A}}=\rho_1\sqrt{1-\rho_1}=\sigma.$$

In this case is :

$$A=y_o+\frac{1}{\Phi^{*2}}k_o=1.865 \text{ and } \sqrt{A}=1.366.$$

$$\sigma=\frac{q}{CA\sqrt{A}}=0.2335 \text{ and } \rho_1=0.2741.$$

$$y_1=\rho_1 \cdot A=0.511=0.51 \text{ m}$$

$$a=\frac{y_1}{\Psi}=0.81 \text{ m and } n=\frac{y_o}{a}=2.15.$$

The advantage of using the $\rho-\sigma$—method for this calculation is self-explanatory.

10.3. *The flow conditions over a bund*

The steady uniform flow exists in a flume. It is to exhibit what kind of flow conditions may be possible on account of a hump and those in the cases of (fig. 7):

(*a*) Mild basic flow (subcritical region)
(*b*) Steep basic flow (supercritical region)

The heads in the undisturbed conditions have the index (u) and those over the bund (similar to a broad-crested weir) have the index (w). In these considerations the loss of head in the zone of the hump may be neglected.

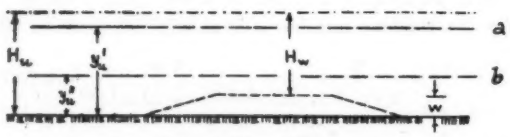
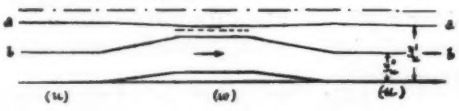


Fig. 7: Steady uniform flow in a flume.
(a) Mild basic flow.
(b) Steep basic flow.

In the stage where the original energy level with head H_u over the base will even be sufficient to discharge the given flowrate over the bund, the concerned head of the bund will be indicated in term of w_c. Further three general cases are to be distinguished.

1st case : $w<w_c$ or $H_{min}+w<H_u$

Therefore follows (fig. 8) $H_u-w=H_w>H_{min}$ and $y_w \lessgtr y_c$.



$y'_u > y'_w > y_c$
$y''_u < y''_w < y_c$

Fig. 8: Flow over a bund: $w<w_c$

The discharge is possible under the existing energy level.

2nd case : $w=w_c$ or $H_{min}+w=H_u$

[*Continued on page* 26]

Table 1: Values $\frac{y}{y_c}$ and $\frac{H}{y_c}$

$\frac{y}{y_c}$	$\frac{H}{y_c}$
5.00	5.0200
3.00	3.0655
2,90	2.9595
2.80	2,8638
2.70	2.7686
2.60	2.6739
2.50	2.5800
2.40	2.4868
2.30	2.3945
2,20	2.3033
2.10	2.2134
2.00	2.1250
1.90	2.0385
1.80	1.9543
1.70	1.8730
1.60	1.7953
1.50	1.7222
1.40	1.6551
1.30	1.5950
1.20	1.5472
1.10	1.5132
1.00	1.5000
0.90	1.5173
0.80	1.5812
0.70	1.7204
0.60	1.9880
0.50	2.5000
0.40	3.5250
0.30	5.8555
0.20	12.7000
0.10	50.1000
0	∞

Table 2: Values ρ and σ

Δρ	ρ	σ	Δσ
	1.000	0.0000	0.0446
0.002	0.998	0.0446	184
	0.996	0.0630	140
	0.994	0.0770	117
	0.992	0.0887	103
	0.990	0.0990	92
	0.988	0.1082	85
	0.986	0.1167	78
	0.984	0.1245	72
	0.982	0.1317	69
	0.980	0.1386	65
	0.978	0.1451	61
	0.976	0.1512	59
	0.974	0.1571	55
	0.972	0.1626	54
	0.970	0.1680	52
	0.968	0.1732	49
	0.966	0.1781	48
	0.964	0.1829	46
	0.962	0.1875	45
	0.960	0.1920	43
	0.958	0.1963	42
	0.956	0.2005	41
	0.954	0.2046	40
	0.952	0.2086	38
	0.950	0.2124	38
	0.948	0.2162	36
	0.946	0.2198	36
	0.944	0.2234	35
	0.942	0.2269	34
	0.940	0.2303	33
	0.938	0.2336	32
	0.936	0.2368	31
	0.934	0.2399	31
	0.932	0.2430	31
	0.930	0.2461	29
	0.928	0.2490	29
	0.926	0.2519	28
	0.924	0.2547	28
	0.922	0.2575	27
	0.920	0.2602	27
	0.918	0.2629	26
	0.916	0.2655	25
	0.914	0.2680	25
	0.912	0.2705	25
	0.910	0.2730	24
	0.908	0.2745	24
	0.906	0.2778	23
	0.904	0.2801	23
0.002	0.902	0.2824	22
0.005	0.900	0.2846	54
	0.895	0.2900	52
	0.890	0.2952	49
	0.885	0.3001	47
	0.880	0.3048	46
	0.875	0.3094	43
	0.870	0.3137	41
	0.865	0.3178	40
	0.860	0.3218	38
	0.855	0.3256	36
	0.850	0.3292	35
	0.845	0.3327	33
	0.840	0.3360	

Δρ	ρ	σ	Δσ
	0.840	0.3360	32
0.005	0.835	0.3392	30
	0.830	0.3422	29
	0.825	0.3451	28
	0.820	0.3479	26
	0.815	0.3505	26
	0.810	0.3531	24
	0.805	0.3555	23
	0.800	0.3578	22
	0.795	0.3600	20
	0.790	0.3620	20
	0.785	0.3640	19
	0.780	0.3659	17
	0.775	0.3676	17
	0.770	0.3693	15
	0.765	0.3708	15
	0.760	0.3723	14
	0.755	0.3737	13
	0.750	0.3750	12
	0.745	0.3762	11
	0.740	0.3773	11
	0.735	0.3784	9
	0.730	0.3793	9
	0.725	0.3802	8
	0.720	0.3810	7
	0.715	0.3817	6
	0.710	0.3823	6
0.005	0.705	0.3829	0.000506
0.002	0.700	0.383406	0.000177
	0.698	0.383583	165
	0.696	0.383748	154
	0.694	0.383902	142
	0.692	0.384044	132
	0.690	176	120
	0.688	296	109
	0.686	405	98
	0.684	503	87
	0.682	590	76
	0.680	666	65
	0.678	731	55
	0.676	786	44
	0.674	830	33
	0.672	863	23
	0.670	886	12
0.002	0.668	898	2
0.001	0.667	9.000	01
	2/3	0.384900	05
0.001			8
0.002	0.666	899	19
	0.664	891	29
	0.662	872	39
	0.660	843	50
	0.658	804	60
	0.656	754	69
	0.654	694	80
	0.652	625	89
	0.650	545	100
	0.648	456	110
	0.646	356	119
	0.644	247	128
	0.642	128	138
	0.640	0.384000	148
	0.638	0.383862	
	0.636	714	

Δρ	ρ	σ	Δσ
	0.636	0.383714	157
0.002	0.634	557	167
	0.632	390	176
	0.630	214	185
	0.628	0.383029	195
	0.626	0.382834	204
	0.624	630	214
	0.622	416	222
	0.620	194	232
	0.618	0.381962	241
	0.616	721	249
	0.614	472	259
	0.612	213	268
	0.610	0.380945	276
	0.608	669	286
	0.606	383	295
	0.604	0.380088	303
0.002	0.602	0.379785	312
0.005	0.600	0.379473	713
	0.595	0.3787	9
	0.590	0.3778	9
	0.585	0.3789	10
	0.580	0.3759	10
	0.575	0.3749	11
	0.570	0.3738	12
	0.565	0.3726	11
0.005	0.560	0.3715	13
	0.555	0.3702	12
	0.550	0.6690	14
	0.545	0.3676	14
	0.540	0.3662	14
	0.585	0.3648	15
	0.530	0.3633	15
	0.525	0.3618	15
	0.520	0.3603	16
	0.515	0.3587	17
	0.510	0.3570	17
	0.505	0.3553	17
0.005	0.500	0.3536	37
0.010	0.490	0.3499	38
	0.480	0.3461	39
	0.470	0.3422	42
	0.460	0.3380	43
	0.450	0.3337	44
	0.440	0.3298	47
	0.430	0.3246	47
	0.420	0.3199	50
	0.410	0.3149	51
	0.400	0.3098	52
	0.390	0.3046	54
	0.380	0.2992	55
	0.370	0.2937	57
	0.360	0.2880	58
	0.350	0.2822	60
	0.340	0.2762	61
	0.330	0.2701	62
	0.320	0.2639	64
	0.310	0.2575	65
	0.300	0.2510	66
	0.290	0.2444	68
	0.280	0.2376	69
	0.270	0.2307	70
	0.260	0.2237	72
	0.250	0.2165	73
	0.240	0.2092	74
	0.230	0.2018	75
	0.220	0.1943	76
	0.210	0.1867	78
	0.200	0.1789	79
	0.190	0.1710	80
	0.180	0.1630	81
	0.170	0.1549	83
	0.160	0.1466	83
	0.150	0.1383	85
	0.140	0.1298	85
	0.130	0.1213	87
	0.120	0.1126	88
	0.110	0.1038	89
	0.100	0.0949	90
	0.090	0.0859	92
	0.080	0.0767	92
	0.070	0.0676	93
	0.060	0.0582	95
	0.050	0.0487	95
	0.040	0.0392	96
	0.030	0.0296	96
	0.020	0.0198	98
	0.010	0.0100	98
	0.000	0.0000	100

Table 3. *Values* ρ', $\Delta\rho$ *and* σ *for* $1 \geqq \rho' \geqq \frac{1}{2}$.

ρ'	ρ''	$\Delta\rho$	σ
1.000	0.0000	1.0000	0.0000
0.990	0.1046	0.8854	0.0990
0.980	0.1504	0.8296	0.1386
0.970	0.1862	0.7838	0.1680
0.960	0.2170	0.7430	0.1920
0.950	0.2444	0.7056	0.2124
0.940	0.2694	0.6706	0.2303
0.930	0.2925	0.6375	0.2461
0.920	0.3142	0.6058	0.2602
0.910	0.3347	0.5753	0.2730
0.900	0.3541	0.5459	0.2846
0.890	0.3727	0.5173	0.2925
0.880	0.3905	0.4895	0.3048
0.870	0.4075	0.4625	0.3137
0.860	0.4240	0.4360	0.3218
0.850	0.4399	0.4101	0.3292
0.840	0.4552	0.3848	0.3360
0.830	0.4701	0.3599	0.3422
0.820	0.4846	0.3354	0.3479
0.810	0.4986	0.3113	0.3531
0.800	0.5123	0.2877	0.3578
0.790	0.5256	0.2644	0.3620
0.780	0.5386	0.2414	0.3659
0.770	0.5513	0.2187	0.3693
0.760	0.5636	0.1964	0.3723
0.750	0.5757	0.1743	0.3750
0.740	0.5875	0.1525	0.3773
0.730	0.5990	0.1310	0.3793
0.720	0.6103	0.1097	0.3810
0.710	0.6214	0.0886	0.3823
0.700	0.6322	0.0678	0.3834
0.690	0.6428	0.0472	0.3842
0.680	0.6532	0.0268	0.3847
0.670	0.6633	0.0067	0.3849
$\frac{1}{2}$	$\frac{1}{2}$	0.0000	0.3849

Table 5 : *Values* n'', Δn *and* m *for* $\frac{1}{2} \geqq n' \geqq 1$.

n'	n''	Δn	m
1.50	0.0000	1.5000	0.0000
1.48	0.1824	1.2976	0.2960
1.46	0.2498	1.2102	0.4129
1.44	0.3254	1.1146	0.4988
1.42	0.3794	1.0406	0.5680
1.40	0.4275	0.9725	0.6261
1.38	0.4713	0.9087	0.6761
1.36	0.5119	0.8481	0.7197
1.34	0.5498	0.7902	0.7580
1.32	0.5863	0.7337	0.7920
1.30	0.6196	0.6804	0.8222
1.28	0.6519	0.6281	0.8490
1.26	0.6828	0.5772	0.8729
1.24	0.7125	0.5275	0.8942
1.22	0.7409	0.4791	0.9129
1.20	0.7684	0.4316	0.9295
1.18	0.7949	0.3851	0.9440
1.16	0.8206	0.3394	0.9565
1.14	0.8455	0.2945	0.9673
1.12	0.8695	0.2505	0.9764
1.10	0.8928	0.2072	0.9839
1.08	0.9155	0.1645	0.9898
1.06	0.9374	0.1226	0.9944
1.04	0.9588	0.0812	0.9976
1.02	0.9798	0.0402	0.9994
1.00	1.0000	0.0000	1.0000

Table 4 : values n and m

n	m	Δm	n	m	Δm	n	m	Δm
1,50	0.0000	0.2107	1.00	1.0000	0.0002	0.50	0.7071	0.0107
1,49	0.2107	0.0853	0.99	0.9998	0.0004	0.49	0.6964	0.0109
1.48	0.2960	0.0640	0.98	0.9994	0.0007	0.48	0.6855	0.0110
1.47	0.3600	0.0529	0.97	0.9987	0.0010	0.47	0.6745	0.0111
1.46	0.4129	0.0456	0.96	0.9977	0.0013	0.46	0.6634	0.0113
1.45	0.4585	0.0403	0.95	0.9964	0.0016	0.45	0.6521	0.0115
1.44	0.4988	0.0363	0.94	0.9948	0.0018	0.44	0.6406	0.0116
1.43	0.5351	0.0329	0.93	0.9930	0.0021	0.43	0.6290	0.0116
1.42	0.5680	0.0303	0.92	0.9909	0.0024	0.42	0.6174	0.0120
1.41	0.5983	0.0278	0.91	0.9885	0.0026	0.41	0.6054	0.0121
1.40	0.6261	0.0258	0.90	0.9859	0.0029	0.40	0.5933	0.0122
1.39	0.6519	0.0242	0.89	0.9830	0.0031	0.39	0.5811	0.0124
1.38	0.6761	0.0225	0.88	0.9799	0.0034	0.38	0.5687	0.0125
1.37	0.6986	0.0211	0.87	0.9765	0.0035	0.37	0.5562	0.0126
1.36	0.7197	0.0197	0.86	0.9730	0.0039	0.36	0.5436	0.0128
1.35	0.7394	0.0186	0.85	0.9691	0.0040	0.35	0.5308	0.0129
1.34	0.7580	0.0175	0.84	0.9651	0.0043	0.34	0.5179	0.0131
1.33	0.7755	0.0165	0.83	0.9608	0.0045	0.33	0.5048	0.0132
1.32	0.7920	0.0155	0.82	0.9563	0.0048	0.32	0.4916	0.0134
1.31	0.8075	0.0148	0.81	0.9515	0.0050	0.31	0.4782	0.0134
1.30	0.8223	0.0137	0.80	0.9465	0.0051	0.30	0.4648	0.0137
1.29	0.8360	0.0130	0.79	0.9414	0.0054	0.29	0.4511	0.0137
1.28	0.8490	0.0123	0.78	0.9360	0.0056	0.28	0.4374	0.0139
1.27	0.8613	0.0116	0.77	0.9304	0.0059	0.27	0.4235	0.0142
1.26	0.8729	0.0110	0.76	0.9245	0.0060	0.26	0.4093	0.0140
1.25	0.8839	0.0108	0.75	0.9185	0.0062	0.25	0.3953	0.0143
1.24	0.8942	0.0096	0.74	0.9123	0.0064	0.24	0.3810	0.0144
1.23	0.9038	0.0091	0.73	0.9059	0.0066	0.23	0.3666	0.0146
1.22	0.9129	0.0086	0.72	0.8993	0.0068	0.22	0.3520	0.0147
1.21	0.9215	0.0080	0.71	0.8925	0.0071	0.21	0.3373	0.0148
1.20	0.9295	0.0075	0.70	0.8854	0.0072	0.20	0.3225	0.0150
1.19	0.9370	0.0070	0.69	0.8782	0.0074	0.19	0.3075	0.0150
1.18	0.9440	0.0065	0.68	0.8708	0.0076	0.18	0.2925	0.0152
1.17	0.9505	0.0060	0.67	0.8632	0.0077	0.17	0.2773	0.0154
1.16	0.9565	0.0056	0.66	0.8555	0.0080	0.16	0.2619	0.0154
1.15	0.9621	0.0052	0.65	0.8475	0.0081	0.15	0.2465	0.0156
1.14	0.9673	0.0047	0.63	0.8394	0.0084	0.14	0.2309	0.0157
1.13	0.9720	0.0044	0.65	0.8310	0.0085	0.13	0.2152	0.0158
1.12	0.9764	0.0040	0.62	0.8225	0.0086	0.12	0.1994	0.0160
1.11	0.9804	0.0034	0.61	0.8139	0.0089	0.11	0.1834	0.0161
1.10	0.9838	0.0032	0.60	0.8050	0.0090	0.10	0.1673	0.0162
1.09	0.9870	0.0028	0.59	0.7960	0.0092	0.09	0.1511	0.0163
1.08	0.9898	0.0025	0.58	0.7868	0.0094	0.08	0.1348	0.0164
1.07	0.9923	0.0021	0.57	0.7774	0.0096	0.07	0.1184	0.0166
1.06	0.9944	0.0017	0.56	0.7678	0.0097	0.06	0.1018	0.0167
1.05	0.9961	0.0014	0.55	0.7581	0.0099	0.05	0.0851	0.0168
1.04	0.9975	0.0010	0.54	0.7482	0.0100	0.04	0.0683	0.0169
1.03	0.9985	0.0009	0.53	0.7382	0.0102	0.03	0.0514	0.0170
1.02	0.9994	0.0004	0.52	0.7280	0.0104	0.02	0.0344	0.0171
1.01	0.9998	0.0002	0.51	0.7176	0.0105	0.01	0.0173	0.0173
1,00	1.0000		0.50	0.7071		0.00	0.0000	

Israel's Master Plan for Irrigation

Israel's water experts have worked out a master plan which can more then double the country's area of irrigated land—at present 1.1 million dunams (about 27,000 acres). This can be done by increasing the country's water supply from its present 1000 million cubic metres to 1900 m. cu.m. (500 milliard U.S. gals.) at a cost of IL. 250 million.

This is technically and financially within Israel's power. The experts of Tahal, the National Water Planning Authority, have worked out an overall plan for the whole country, involving an elaborate interlocking system of canals, pipelines, and tunnelled conduits, with storage basins, pumping works and hydroelectric power stations, to supplement the existing regional pipeline networks.

The country's water problem can be summarized in one sentence: the North has plentiful water resources but only little land left untilled; the South has virtually unlimited land reserves but very little water. The problem, therefore, is to carry the North's excess to the parched South, collecting on the way all the minor sources and regional water systems and fashioning them into an integrated national network.

The present and future water supply situation is as follws :

	Annual Quantity of Water (in million cu.m.)* Present	Future	Total
1. Water network built before establishment of State	230		
2. Regional water systems built since establishment of State	570		
3. Five regional water systems ancillary to Jordan-Negev scheme			
(a) parts already completed	200		1000
(b) parts not yet built		400	
4. Jordan-Negev Scheme (not yet built)	500		900
Total supply when all schemes completed:			1900

	Annual Quantity (in million cu.m.)
Rivers	700
Spring	200
Underground water and Return Flows	830
Floodwater and Reclaimed Sewage ..	170
	1,900

The Jordan-Negev Scheme

The most ambitious and far-reaching project within the overall plan is the River Jordan-Negev Scheme. 375 million cubic metres of the Jordan's waters are to be carried annually over a distance of 185 kilometres (116 miles) to the Negev through a succession of open canals, reservoirs giant pipe conduits and tunnels. The conduits will be made of locally produced 108-inch diameter pre-stressed concrete pipe, and the total length of the three tunnels is 7.8 km.

Three storage basins along the route of the line will serve to equalize seasonal fluctuations in the water supply.

The line will start near the Bnot Ya'cov Bridg , which spans the Jordan River north of Lake Hula, and will end west of Beersheba, where the water will be distributed into regional supply systems. For most of the length of the line, the water will travel by gravity; it will only have to be pumped once to an altitude of about 120 metres at the Beit Netufa Valley. For this purpose a pumping station is to be constructed at Wadi Tufah.

Regional Schemes

The national master plan for irrigation also comprises the following four regional schemes :

The Hula Irrigation Scheme will deliver 100 million cu.m. annually from the Dan River, a tributary of the Jordan in the upper North, to be used mainly for the irrigation of the Hula Valley and the nearby Naphtali hill range. The exploitable altitude difference will be used to produce power for raising the water to the hills.

The Lake Kinneret and Beit She'an Scheme will will add 74 million cu.m from the Sea of Galilee to the Jordan Valley every summer, and supplement the Beit Sh'an area's own 150 million cu.m. regional supply system. In winter the flow is to be reversed and the Beit She'an Valley's excess waters will be channelled through the same pipe into Lake Kinneret.

The Western Galilee and Valley of Jezreel Scheme runs southwards from the Galilean mountains, collecting a total of 150 million cu.m. per annum on the way to fill a large storage basin at Kfar Baruch. Part of this quantity will come from springs and flood waters as well as from reclaimed

Haifa sewage. The water will take care of the needs of Western Galilee, the Zebulun Valley, the Western Jezreel Valley and the towns of Haifa and Acre.

The Yakon-Negev Scheme will deliver 200 million cu.m. a year to the South and the Negev. Most of this quantity will come from the Yarkon River, while part of it will be reclaimed sewage from the Tel Aviv Conurbation.

Problems and Solutions

This large-scale intricate system is bound to give rise to several technical problems, for which ingenious solutions have been proposed.

One of these stems from the fact that, while Lake Kinneret is fed in part by a number of saline springs, the large inflow of water from the River Jordan offsets this by dilution and keeps the waters of the Lake sufficiently sweet. If large quantities of water were diverted from the Jordan before it entered the Kinneret, the latter would become progressively saltier. To prevent this, most of the brackish springs are to be gathered in one channel and, outflanking the Kinneret, are to be carried by pipe to the river south of the Lake.

Another effect of diverting the Jordan would be the drying up of the Dead Sea. If the project were carried out in all its phases, the level of the Dead Sea would drop by 15 metres within 60 years and its shallower, southern part would be completely drained.

This water deficiency is to be made up from the Mediterranean. According to a hydro-electric power project which has been tentatively worked out, an open overland canal is to carry sea-water from the coast near the Kishon River, north of Haifa, to the Jordan River in the Beit She'an Valley. The water would have to be pumped to a height of 58 metres over the coastal hill range but could then flow by gravity to a depth of 280 metres below sea level. A power station would be built to exploit this large altitude differential; its energy production, after deducting the energy used in pumping, is estimated at 750 million kilowatt hours, a year. This sould be compared with the country's total production of electricity, which in 1956 amounted to 1,142 million kilowatt hours, but the whole project of the power station is now being reconsidered in view of the prospects for power generation from nuclear energy.

Additional Water Resources

It should be borne in mind that the National Water Plan does not exhaust all of Israel's water resources. When completed in about ten years' time, it is to be supplemented by various other schemes, such as large-scale rainwater storage in the Negev hill region and desalting of brackish springs.

These and other small projects are raising the country's water supply by 80-100 million cu.m. a year, which allow an additional 150,000-200,000 dunams of land to be brought annually under the plough.

Continued from page 24

Calculation with the Energy-Head

Therefore follows (fig. 9) $H_w = H_{min}$ and $y_w = y_c$.

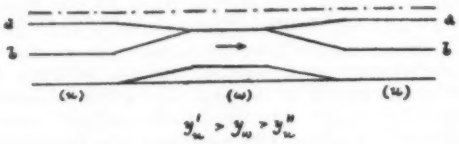


Fig. 9: Flow over a bund: $w = w_c$

In this stage the discharge is even possible under the existing energy level.

3rd case : $w > w_c$ or $H_{min} + w > H_u$

Therefore follows (fig. 10) $H_w = H_{min}$ and $y_w = y_c$.

The original energy level is not high enough to discharge the flowrate over the bund. More energy upstream of the hindrance must be accumulated due to the mounting in level.

Downstream there are two different conditions. In the case of subcritical basic flow ensued the transition from the steep to the mild flow with the hydraulic jump. In the case of supercritical flow, however, there is only a retarded flow in the shooting region.

Conclusions

The application of relative numbers is useful for calculations. The methods, explained for rectangular channels, are naturally possible for other cross sections also. The frequently occurred trapezoidal profile deserves a particular note. There exists for the critical depth the reach

$$\tfrac{3}{5}H \leqq y_c \leqq \tfrac{4}{5}H$$

in which is

$y = \tfrac{3}{5}H$ for rectangular cross section and

$y_c = \tfrac{4}{5}H$ for triangular cross section

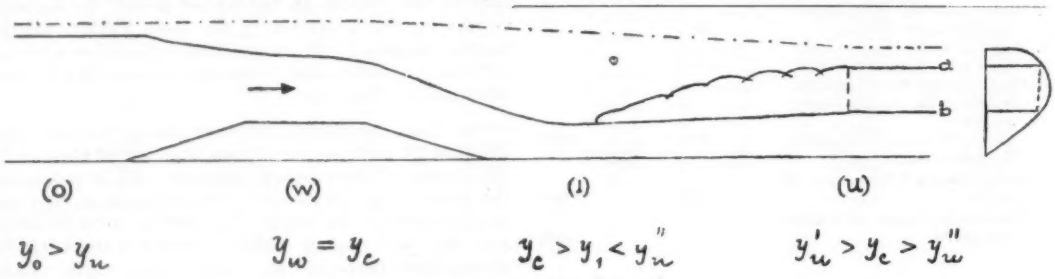


Fig. 10: Flow over a bunt: $w > w_c$

As these two profiles are in any way the limiting profiles of the trapezoidal cross section, a complete adaptation of the ρ--σ—method for this is given by K. Flierl*. It includes self-evident the above mentioned case of rectangular profiles.

Asia's Largest Rubber Factory

India's rubber manufacturing industry is destined to play a key part in fulfilling the country's Five Year Plans. Not only in motor transport, but in industry generally and for the supply of consumer goods, the rubber manufacturing industry is today called on to play a responsible part as one of India's basic industries. It is a mattor for satisfaction, therefore, that the range of rubber products manufactured in India is continually widening and thus helping the industry to meet the vital requirements of numerous branches of the country's oconomy.

The growth of this infant industry has been truly remarkable. Barely 20 years ago, India imported the bulk of her requirements of manufactured rubber goods. In 1935-36, these imports were to the value of Rs. 2 crores; by 1950-51, they had dropped to a mere Rs. 33 lakhs and in the same year, goods to the value of Rs. 1.66 crores were exported. The Government of India has permitted the import of tyres and tubes to meet the recent shortages arising out of the greatly increased demand for these products. It is expected, however, that the expansion programmes now under way will help to correct this position in the not too distant a future.

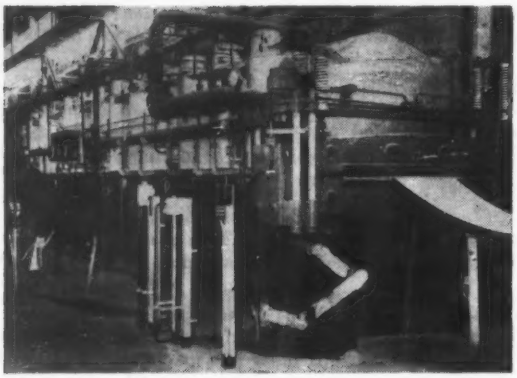
The tempo of economic activity in the country is rising at a rate not known before. This development is very largely due to the growth of heavy industries, power transmission and agriculture, all of which are making increasing demands for rubber products such as rubber covered cables, transmission and vee-belts, conveyor belting and hoses. But the tyre manufacturing section of the industry will have to face the heaviest demand. It is estimated that a fleet of 1,60,000 trucks will be necessary by the end of the Second Plan period to handle the growing goods traffic by road. The production of motor vehicles and bicycles will also increase. By 1960, 57,000 cars and trucks, 12,000 motorcycles and scooters and 12,50,000 bicycles will be manufactured in India per annum. The tyre industry will be required to meet the original equipment and replacement requirements, and it is estimated that by 1960, the demand for automobile tyres will be 16,00,000 and for bicycle tyres 110,00,000 as against the actual production in 1956 of 9,38,400 and 63,20,400 respectively. Besides tyres and tubes the industry supplies a large number of vital components required for the modern automobile such as fan belts, radiator hoses, adhesives for body building, latex foam cushioning, etc.

The first rubber factory in India was established almost 32 years after John Boyd Dunlop, invented the first practicable pneumatic tyre. India is the only country in the world where the rubber manufacturing industry is largely fed with indigenous natural rubber As a result, the industry has firmly teken root within a short period of two decades. The tyre manufacturing section is the mainstay of the industry and large scale tyre manufacture in the country was pioneered by Dunlop in 1936 when they set up a factory in Sahaganj neat Calcutta which comes of age this year. The factory was officially opened by Sir John Anderson, then Governor of Bengal, on the 28th November, 1936. Since then, new plant and machinery have been added from time to time to expand the volume and range of products. This factory is now the largest rubber manufacturing enterprise in Asia.

During the Second World War, the Dunlop Sahaganj factory gave a creditable account of itself and apart from the rapid expansion in the production of tyres and tubes for cars and trucks, aero tyres and tubes were added to the range. The first major post-War development at Sahaganj was the production of quality cycle rims which was of particular significance in view of the setting up of the many new bicycle factories soon after.

Production of Dunlopillo Latex Foam cushioning commenced in 1951 and in course of the last five years output has gone up four-fold. The increasing use of this material in transport, Assembly Houses, cinemas, hotels, hospitals as well as in the home, promises a great future for this product.

The recent extensions to the Sahaganj factory are of particular interest in relation to the Five Year Plans. The belting and hose plants were officially opened by Dr. B. C. Roy, Chief Minister of West Bengal, in December 1952, and it is now turning out conveyor and elevator belting, transmission and industrial vee belts of the best quality which were mostly imported until recently. Long length braided hose by the lead press moulded process, and a number of special types of hoses, hitherto imported, have been added to the range. Recently, Dunlop initiated



The Giant Hydraulic Belting Press at the Sahaganj Factory. Schemes for increasing the production of belting at Sahaganj are now being implemented.

an anti-corrosion and abrasion resistant rubber lining service which has already enabled the Raliways and other enterprises to save valuable foreign exchange.

In the first Five Year Plan period Sahaganj undertook the manufacture, for the first time in India, of tyres for jet aircraft. Another important project now under way is the installation of plant for the production of large earthmover tyres. Numerous expansion schemes are being implemented at Sahaganj to meet the growing demand and a considerable increase in the output of truck and bus tyres, cycle tyres, cycle rims, industrial rubber products and Dunlopillo is planned.

Twenty-one years after the founding of India's first tyre factory, Dunlop are putting up another at Ambattur near Madras which is expected to go into production by the end of 1958. Truck, bus and cycle tyres will be produced here primarily for the needs of the South Indian market.

Radiation Laboratory for Rubber Industry

Opening of a new, fully equipped radiation laboratory, the first of its kind in the rubber industry, has been announced by The Goodyear Tyre & Rubber Company, Akron, Ohio. The laboratory was constructed at a cost of more than $125,000.

As an addition to Goodyear's main research facilities, the new lab. is especially designed for the exploration and development of rubber products which will perform satisfactorily in a radiation environment. Radioactive cobalt 60, which gives off high energy x-rays or gamma rays, will be utilized in this wide, new field of rubber research.

One of the more important projects contemplated in development of radiation resistant airplane tyres which could be used on atomic powered aircraft of the future.

Rubber is particulary susceptibe to radiation and excessive doses are invariably damaging, usually leading to hardening and embrittlement. Using radio-active cobalt, Goodyear scientists will search for the most favourable compounding practices and for chemical additives to improve radiation resistance, along with resistance to heat and oils.

Other goals of the irradiation programme will seek to initiate chemical reactions, polymerization, vulcanization of rubber and to improve physical properties of plastics and resins.

For most types of raw rubber, irradiation results in vulcanization. Among the many possibilities in this field is that vulcanization can be accomplished without adding sulphur or other chemicals. Neither is it necessary to raise the temperature of the rubber.

Choice of cobalt 60 as a radiation source for Goodyear's new laboratory was made largely because a wide variety of materials will be investigated. The radiation field can be made quite effective over large samples such as automobile, truck and airplane tyres with cobalt 60 and it provides a flexibility which is especially desirable as a laboratory tool.

The cobalt 60 is in the form of small "slugs" or cylinders one inch long end one-eighth inch in diameter. Each cylinder is sheathed in aluminum, one-sixteenth of an inch in thickness. Nine of these cylinders are assembled in an aluminum pencil about 10 inches long and Goodyear's source consists of 72 of these pencils.

Cobalt is a comparatively rare, hard metal closely associated with iron and nickel and when subjected to neutron bombardment in an atomic reactor, becomes highly radioactive, giving off intense radiations of its own. Goodyear's source of 2,100 curies of Cobalt 60 was activated in the NRX reactor at Chalk River, Ontario, by Atomic Energy of Canada, Ltd. It was shipped by truck to Ekron in a specially designed lead container weighing four tons.

The modern, air-conditioned laboratory built by Goodyear for its radiation research programme is a ground floor structure, 42 by 24 feet. Inside the lab is a heavily shielded area, known as the "cave", for housing the radioactive source. Next to it is a well-equipped physics and chemistry laboratory for the preparation of materials and test specimens and for the evaluation of results and products of irradiation experiments.

Access to the "cave" from the preparation lab. is gained through a labyrinth with four-foot wide aisles, a design which eliminates the need for any massive, cumbersome shielding door. Walls of the "cave" are made of reinforced concrete, four feet thick and the roof is three feet thick. This shielding is adequate for an anticipated 10,000 curie scurce of cobalt 60 or for about a million curies of the fission by-product, cesium 137, which also can be used in irradiation experiments. There are no radioactive wastes resulting from the use of cobalt 60, and with the shieding employed, there is no possibility of stray radiation affecting any of the surrounding area.

Extensive planning and preparation have been done for the handling of radioactive materials. Now ready for use, the cobalt 60 rests in the "cave" in a concrete and aluminum lined well, three by six feet and 17 feet deep, providing enough water shield for safe operation.

Another distinctive feature of the installation is the elevator in the well by which means the radioactive source can be raised into an aluminum housing atop the well for experiments or lowered to the bottom for storage. With the source under water, scientists can safely enter the cave any time. Direct exposure to the cobalt for as little as three to five minutes would be fatal.

Samples to be irradiated can be placed in the center of the housing for more intense radiation, or throughout the cave around the housing. This arrangement removes practically all limits on the size and number of samples which can be subjected to radiation at one time.

This method also differs from the usual procedures of using radioactive materials with remote controls in air in the limited confines of a lead container, or under water. An installation with remote manipulation is unwieldy and underwater operation is inconvenient as samples to be irradiated must be packaged in water tight containers. Then, too, full effects of radiation cannot be obtained over large volumes under water because of its shielding characteristics.

As the nation's atomic energy programme advances and industrial uses of atomic energy are put into effect, the demand rises for rubber products such as hose, belting, gaskets and tyres wich will perform satisfactorily in a radiation environment.

In chemical processing, radiation can serve as an alternative to heat and chemical agents for energizing or activating molecules and can increase the speed of many chemical reactions. In some cases, it may alter the course of a reaction favourably and yield completely new products.

Use of radioactive materials may open up a wide new field of polymerization research in which radiation should be able to do useful things which cannot be accopmplished by the usual chemical means.

One possibility is the formation of new types of synthetic rubber. Through radiation, it may be possible to add monomers to a polymer already formed, endowing a rubber with selective, advantegeous properties such as resistance to certain types of solvents or low permeability to various gases.

Another possibility is that the monomer might be selected to act as a lubricant in the rubber, resulting in less internal friction and low heat generation from flexing. Radiation cured rubber has excellent aging characteristics or improved resistance to deteriorating effects of heat and oxygen.

The promising field of food pasteurization by radiation is significant for packaging materials such as Goodyear's Pliofilm, as well as for rubber mechanical goods used in food processing and packaging equipment. Proper doses of radiation on plastics can result in improved physical properties, especially for high temperature applications. Other applications will be sought in connection with the many plastic materials produced and used by Goodyear.

Effects of radiation on latex, rubber cements and adhesives used in the rubber industry are practically unexplored and offer many avenues of new product development and improvement.

SPECIAL NUMBER

of

INDIAN JOURNAL OF POWER & RIVER VALLEY DEVELOPMENT

ANDHRA PRADESH ELECTRICITY DEVELOPMENT—a comprehensive reference publication covering all aspects of electricity development in Andhra Pradesh.

Contributors include:

B.R. Somayajulu, Chief Engineer, Electricity ; S.A. Quader, Addl. Chief Engineer, Electricity ; B.P. Shastry, Executive Engineer ; I. Basava Raju, Asstt. Executive Engineer.

PRICE : RS. 3/00

Place your orders with :

The Manager

INDIAN JOURNAL OF POWER & RIVER VALLEY DEVELOPMENT

6/2, Madan Street, Calcutta 13.

C. A. Parsons Co. Ltd.

Large Steam Turbo-Generator Sets

At the Heaton Works of C.A. Parsons & Co. Ltd., Newcastle Upon Tyne, England, work is proceeding on many large steam turbo-generator sets of advanced design. Machines under construction include 100, 120 and 200 MW sets arranged in one line and 200, 300 and 550 MW cross-compounded sets arranged in two lines.

The 550 MW set is for the new Thorpe Marsh staton of the Central Electricity Generating Board and C.A. Parsons are supplying the turbo-generator set, together with the associated condensing and feed heating plant. This machine will be the largest steam turbo-generator set in the world. A description of this 550 MW set is given below.

The turbine will operate with steam at a pressure of 2,300 lb./sq.in. at the stop valve and a temperature of 1050°F with reheating to 1050°F, the steam being supplied to the machine through two steam chests arranged on each side of the high pressure cylinder.

The unit consists of two lines arranged in line ahead, each line comprising four cylinders driving a 275 MW three phase generator.

All eight main cylinders are of the double-flow type with the high-pressure cylinder on "A" line taking the 550 MW steam flow. From the exhaust of this cylinder the steam is reheated and passed to the first intermediate-pressure cylinder on "B" line. On leaving this cylinder the steam divides equally between duplicate second intermediate-pressure cylinders, one on each line. Final expansion of the steam is then through two low-pressure cylinders on each line.

A single row velocity wheel is used in the initial stage of the high-pressure cylinder and first intermediate-pressure cylinder, the remaining blading and all the blading in the other cylinders being of the reaction type. Seven stage feed water heating is employed to heat the feed water to a temperature of 486°F.

The generators will operate at 18,000 volts ·85 P.F., 50 cycles per second when driven by the turbine at 3,000 r.p.m. The rotors are of the direct gas-cooled type, operating in hydrogen at a pressure of 45 lb./sq.-in. Each stator has a direct cooled winding, by means of demineralised water circulated through hollow conductors. General construction of the stators and rotors follows normal practice with minor modifications being made for arrangement of the gas circuits and coolers.

Excitation for each generator is provided by a main and pilot exciter driven from the generator rotor shaft through reduction gearing.

Both exciters are separate units with their armature shafts being solidly coupled. Ventilation of the exciters is effected by an enclosed air circuit system, the air being circulated by a blower mounted on the pinion of the gear drive to the main exciter shaft.

Letter to the Editor

Dated : 25-2-1958.

Dear Sir,

From the article "Silt in relation to Irrigation and Power Projects" by Shri K. M. Tiwari appearing in your November 1957 issue, I can see that the serious difficulties due to silting of reservoirs are being realised. Though late, the fact that attention is being paid to the reduction in the holding capacity of the reservoir and that cures are being suggested is a good sign. In the article on the 'Mangla Dam Project' appearing in the same issue, the question of siltation has been considered in detail. At the end of para 3 under 'Siltation' the article states that the dead storage portion of that reservoir will be filled up in 30 years ; the article further states that the whole reservoir will be silted up in 100 to 150 years. It is also stated that the cost of the Project is proposed to be amortized in a much smaller period viz. 50 years. Leaving off the actual figures of years involved, the fact remains that the period for siltation is very small.

Regarding the afforestation proposed by Shri Tiwari three important points need elucidation.

(1) What is the number of years that will be required by an average flat area before forests can be grown in that area proposed to be afforested ? and how much capacity of the reservoir will have been lost due to silting in that period ?

At page 28 of the November 1957 issue Shri Tiwari says that a suitable thickness of soil cover will form within a decade. What % of silt will such 'one decade thickness' of soil-cover arrest and how much will go into the reservoir and what effect will that have on (2) below needs to be clarified. Even more important than (1) in a very large number of cases, is the following issue (2).

(2) What effect will the deep layer of leaves and twigs and the lower layer of humus have over the run-off from the catchment, particularly in a year of minimum rainfall ?

It is no use only theorizing on either ? We want actual figures. If the run-off from the catchment is going to be reduced considerably, the cure will be worse than the disease.

Point No. 3 below also need careful consideration.
(3) :—What will be the cost, per average square mile of afforestation, to be borne by the state ?

Of the three points, probably (2) above is the most important and will have very far-reaching effects. When the "Central Water and Power Commission" make observations, they should measure and publish the figures of run-off per square mile, (or per other suitable unit) in the area not covered with forest and compare it with that from the area covered with forest. I suppose Shri Tiwari can write *from actual data* about (1) and (3).

Yours faithfully,

N. S. Joshi

Two Major Lessons

Not only the engineers and the administrators in river valley projects but the whole country has something to learn from the Public Enquiry made on the Life Insurance Corporation Investments. Therefore it would not be proper to disregard or ignore the Report with an air implying that it does not concern a journal like ours.

The Enquiry teaches us two major lessons, if not more. We shall not go into the details of the subject as we may get lost in the mass of evidence. Instead, let us concentrate on the essence of the matter.

The most important fact highlighted by the Enquiry is the devastating attitude of self-surrender practised by the Chairman and the Managing Director of the L. I. C., two very senior officials with different backgrounds. It shows how crucially and critically the integrity and independence of an institution depends, not merely on the laws and rules, but on the character and integrity of *individuals*. Unfortunately now a days so much emphasis is laid on the *form* an institution takes—private or pulic—that it is forgotten, or atleast minimised, that the real factor in the efficiency and the ability of a given institution depends so much on the character and ability of the persons who man it at the top. If attention from this focal point is once removed, the phenomenon of self-surrender as exemplified in the LIC is bound to be repeated.

Is this phenomena of paralysis of one's judgement or of trying to toe the line of the higher-powers-that-be at the cost of discharging one's own responsibilities fearlessly an isolated one? The answar is decidedly in the negative. Rather, the naked truth is that this tendency is widely prevalent practically at all levels of government, both Central and State. So our responsibility does not end with condemning the two officials concerned. We must frankly and fully take cognisance of this most corroding disease prevalent in the administration and try to find out why it happens and persists. Of course there will be a natural tendency to find fault in the *system*, but it would pay greater dividends if we also examined our own selves and the inner motivations of those who surrender judgement and practise sycophancy on the one hand, and of those who feel happy if they are surrounded by persons who would like to please the boss at any cost. A system may be faulty—no system of human relations can be perfect. But it would be escaping the real issue if we tended to put all the blame on the system; for, after all, a system is only a formal expression of our own personalities, of the interaction of our motivations. Therefore the first task of the Vaidyanathans and Kamaths on the one hand, and of Patels on the other is to examine their own true selves. Integrity of character and self-respect and self-reliance is essentially a personal, an individualistic matter. It can grow only out of personal effort; an improved system can at best help the process but it is not the process itself.

The second outstanding lesson of the Enquiry is contained in the following recommendations of Mr. Justice Chagla:

"That Government should not interfere with the working of autonomous corporations; that if they wish to interfere they should not shirk the responsibility of giving directions in writing.

"That if the executive officers of the Corporation are to be appointed from the Civil Services, it should be impressed upon them that they owe a duty and loyalty to the Corporation and that they should not permit themselves to be influenced by senior officials of Government or surrender their judgement to them. If they feel that they are bound to obey the orders of these officials, they must insist on these orders being in writing".

The first recommendation is so obvious that it at first reading appears to be superfluous. But the very fact that it had to be made shows to what extent statutory corporations have been undermined of their very meaning and existence. This is not only true of the L. I. C. but, as we and others have pointed out again and again without any effect, of the D.V.C. also. In fact the real situation is that the term "antonomous corporation" is just a shibboleth and only another name of the Government department. The idea of autonomous administration signifies a definite attitude behind it distinct from the traditional governmental administration. It appears to us that our political leadership has not fully grasped its significance and that is the reason why autonomous corporations inspite of their formal existence are really fictions. Possibly if their meaning is fully understood, our legislators and ministers will not approve of it and reject it. But that would be a far more honest practice than propping up a myth.

If this has been the experience of the L.I.C. which had only one master above it, namely the centre, one can easily imagine the situation the DVC has to go through when it has to please three masters.

In the case of the DVC again, we have had ICS men and still have them as Chairman and members. While we have nothing against them personally, we feel it our duty to remark that at least on some occasions it appeared to us from outside that their membership of the Service exercised a strain on their functioning as primary guardians and officers of the Corporation. This indeed is inevitable, particularly in the present climate of political administration where unwritten "directives" are frequent and autonomy is not understood in its real sense. What actually happens in other autonomous and semi-autonomous bodies like the Project Control Boards, Railways, Airways Corporations, Private Limited Companies floated by Government such as Sindri, etc. can only be guessed.

We therefore strongly recommend the broader principle implied by Mr. Justice Chagla, namely, that those who become members of a corporation must become free from Governmental influence and try to serve the Corporation as their primary trust and responsibility.

The importance of these principles is not academic. "In our expanding economy and in view of the goal that we have set before us of having a socialistic pattern of society, it is inevitable that in future more and more statutory corporations will be set up which will have to administer important matters and also handle a large volume of public funds and the question which the government and the Parliament will have to debate and decide will be what is the nature of relationship that should exist between Govt. and these corporations" (J. Chagla). Therefore let us face them now and face them squarely too.

The L.I.C. Enquiry has done one tremendous good—it has shaken our sense of complacency from inside, as it were. But unless we also think out constructively and learn the bitter lessons and apply them in our own personal and public conduct, a peculiar kind of cynicism and destructive mentality will emerge so that whatever has been built so far will crash to pieces before our very eyes. Such is the meaning and impact of moral instability that surrounds us.

Our Contributors

Mr. S. K. Patil is Minister for Irrigation and Power in the Government of India. His robust commonsense and forthright presentation of his convictions is welknown. This speech created quite a stir of confidence among the men in the electricity supply industry.

Mr. D. C. Bharadwaj joined the Lahore Electric Supply Co. Ltd. in 1933 after graduation in Electrical Engineering with Honours. In 1944 he joined the Aluminium Corporation of India and became Chief Engineer of their works at Jaykaynagar in 1957. In 1951 he joined the Ahmedabad Electricity Co. Ltd. and is at present Superintendent of their Power Stations, "A," "B" and "C" at Sabarmati.

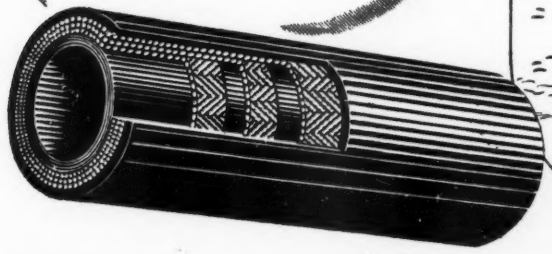
Mr. G. A. Narasimharao is at present Chief Engineer of the Nagarjunsagar Project Canals. He was in charge of the Krishna Barrage Project, the longest of all the barrages so far constructed in India. He has already earned a name for himself as an outstanding construction engineer that the country possesses.

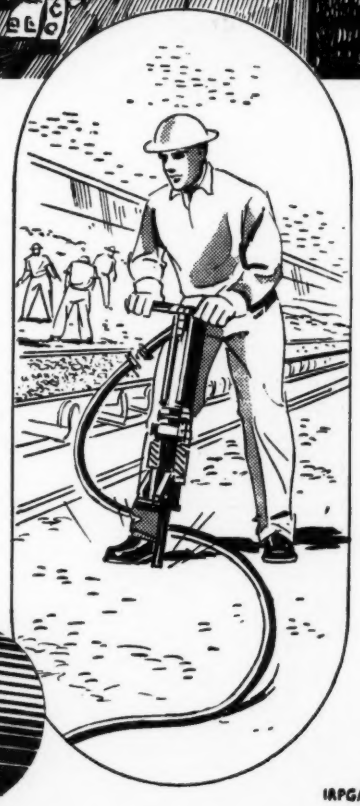
Dr. Ing. Paulgerhard Franke contributes this second article in our journal, the earlier one appearing in our December, 1957 issue.

Don't delay Convey by GOODYEAR BELT

For the transportation of large quantities of bulk materials more engineers the world over, are specifying Goodyear Conveyor Belts. These belt conveyor systems have proved speedier than intermittent haulage, more versatile and economical.

ON TOUGH CONSTRUCTION JOBS. Use Goodyear Pneumatic Tool Hose specification No. 372 currently being specified by Dam projects in India.



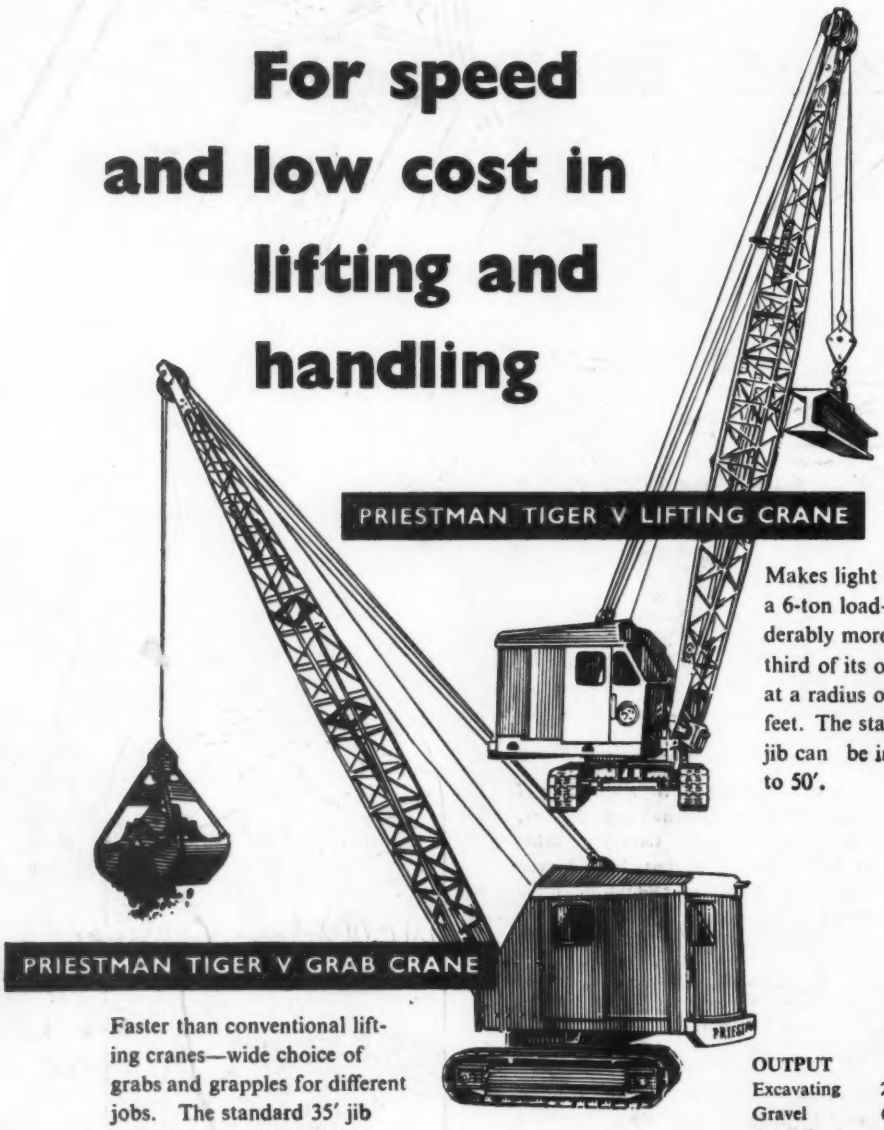


IAPG/37

Printed and published by P. K. Menon from Inland Printing Works 60/3 Dharamtala Street, Calcutta 13
Editorial & Managerial Office : 6/2 Madan Street, Calcutta 13

Regd. No. C 3873

For speed and low cost in lifting and handling



PRIESTMAN TIGER V LIFTING CRANE

Makes light work of a 6-ton load—considerably more than a third of its own weight—at a radius of eleven feet. The standard 35′ jib can be increased to 50′.

PRIESTMAN TIGER V GRAB CRANE

Faster than conventional lifting cranes—wide choice of grabs and grapples for different jobs. The standard 35′ jib can be increased to 50′ if necessary.

OUTPUT	Per hour
Excavating	25 cu. yds.
Gravel	60 cu. yds.
Small Coal	60 cu. yds.

PRIESTMAN TIGER V EQUIPMENT

TRACTORS (INDIA) LIMITED
Post Box 323, Calcutta
Post Box 66, Lucknow.

LARSEN & TOUBRO LIMITED
Post Box 278, Bombay
Post Box 5247, Madras

WILLCOX (BUCKWELL-INDIA) PRIVATE LIMITED
Post Box 289, New Delhi
New Colony, Jaipur

TRACTOR & EQUIPMENT CORPORATION (PRIVATE) LIMITED
P.O. Box 279, New Delhi

TE|P|73